OUTLINE

The R5499Z is high voltage tolerance CMOS-based protection IC for over-charge/discharge and over-current of rechargeable one-cell Lithium-ion (Li+)/Lithium polymer battery. The R5499Z can detect over-charge/discharge of Li+ one-cell and excess load current, further include a short circuit protector for preventing large external short circuit current and the excess charge-current. The R5499Z consists of four voltage detectors, a reference unit, a delay circuit, a short circuit detector, an oscillator, a counter, and a logic circuit.

When the R5499Z detects over-charge or over-charge current, the output of COUT pin switches to “L” level, that is, the charger’s negative pin level after the internal fixed delay time. When the R5499Z detects over-discharge or excess discharge current, the output of DOUT pin switches to “L” level after the internal fixed delay time.

After detecting over-charge or excess charge current, the R5499Z can be reset and the output of COUT becomes “H” when a charger is disconnected from the battery pack, and the cell voltage becomes lower than over-charge detector threshold.

However, depending on the characteristics of external components such as MOSFETs, release conditions may be not enough just removing a charger from the battery pack. In that case, a kind of load must be set to release the over-charge detect.

If a charger is continuously connected to the battery pack, even if the cell voltage becomes lower than over-charge detector threshold, over-charge state is not released.

After detecting over-discharge voltage, connect a charger to the battery pack, and when the battery supply voltage becomes higher than over-discharge detector threshold, the R5499Z is released and the voltage of DOUT pin becomes “H”. If the battery discharges into 0V level, recharge current is accepted. Once after detecting excess discharge-current or short circuit, the R5499Z is released and DOUT level becomes “H” with detaching a battery pack from a load system. After detecting over-discharge, supply current is kept extremely low by halting internal circuits’ operation.

When the output of COUT is “H”, by setting the V- pin at equal or lower than the delay shortening mode voltage (Typ. -2.0V), the output delay can be shortened. Especially, the delay time of over charge detector can be reduced into approximately 1/110. Thus, testing time of protector circuit board can be reduced. Output type of COUT and DOUT is CMOS.
FEATURES

- Absolute Maximum Rating ........................................... 30V
- Supply current (At normal mode) ................................. TYP 4.0µA
- Supply current (At standby mode) ......................... MAX 0.1µA

Detector thresholds accuracy
- Over-charge detector threshold ................................... ±12mV (0°C ≤ Ta ≤ 50°C)
- Over-discharge detector threshold .............................. ±2.5%
- Excess discharge current threshold ......................... ±5mV
- Excess charge current threshold ............................... ±15mV
- Short detector threshold ............................................... ±50mV

Detector thresholds range
- Over-charge detector threshold ............................... 4.3V to 4.6V in step of 0.005
- Over-discharge detector threshold ....................... 2.0V to 3.0V in step of 0.050
- Excess discharge current threshold .................... Code_AC: 0.055V to 0.080V in step of 0.005
  Code_AD: 0.030V to 0.050V in step of 0.005
- Excess charge current threshold ......................... -0.050V to -0.100V in step of 0.005
- Short current threshold ................................................. 0.150V or 0.230V (selectable)

Output delay time
- Over-charge detector Output Delay ............................ 1.0s
- Over-discharge detector Output Delay ......................... 32ms
- Excess discharge current detector Output Delay .... 128ms
- Excess charge current detector Output Delay .......... 8ms
- Short detector Output Delay ........................................ 250µs

Functions
- Output Delay Time Shorting Function
- At COUT is “H”, if V- level is set at –2.0V, the Output Delay time of detect the over-charge and over-discharge can be reduced. (Delay Time for over-charge becomes about 1/110 of normal state.)
- Conditions for release over-charge detector ............... Latch type
- Conditions for release over-discharge detector .......... Latch type
- Package ............................................................... WLCSP-6-P4

APPLICATIONS
- Li+ / Li Polymer protector of over-charge, over-discharge, excess-current for battery pack
- High precision protectors for smart-phones and any other gadgets using on board Li+ / Li Polymer battery
**SELECTION GUIDE**

The input threshold of over-charge, over-discharge, excess discharge current, and the package and taping can be designated.

**Selection Guide**

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Package</th>
<th>Quantity per Reel</th>
<th>Pb Free</th>
<th>Halogen Free</th>
</tr>
</thead>
<tbody>
<tr>
<td>R5499Zxxx$+--E2-F</td>
<td>WLCSP-6-P4</td>
<td>5,000 pcs</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

xxx: Set Voltage Code
Refer to **R5499Z Code List**.

$: Delay Time Code

<table>
<thead>
<tr>
<th>Code</th>
<th>$t_{VDET1}$ [s]</th>
<th>$t_{VDET2}$ [ms]</th>
<th>$t_{VDET3}$ [ms]</th>
<th>$t_{VDET4}$ [ms]</th>
<th>$t_{SHORT}$ [$\mu$s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>32</td>
<td>128</td>
<td>8</td>
<td>250</td>
</tr>
</tbody>
</table>

*: Function Code

<table>
<thead>
<tr>
<th>Code</th>
<th>Return from Over-Charge</th>
<th>Return from Over-Discharge</th>
<th>$V_{DET3}$</th>
<th>$V_{SHORT}$</th>
<th>0-V Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Latch</td>
<td>Latch</td>
<td>0.055V to 0.080V</td>
<td>0.150V / 0.230V</td>
<td>OK</td>
</tr>
<tr>
<td>D</td>
<td>Latch</td>
<td>Latch</td>
<td>0.030V to 0.050V</td>
<td>0.150V / 0.230V</td>
<td>OK</td>
</tr>
</tbody>
</table>

**Product Code List**

**R5499Z Code List**

<table>
<thead>
<tr>
<th>Code</th>
<th>Set Voltage [V]</th>
<th>Delay Time</th>
<th>Function</th>
<th>0-V Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$V_{DET1}$</td>
<td>$V_{DET2}$</td>
<td>$V_{DET3}$</td>
<td>$V_{DET4}$</td>
</tr>
<tr>
<td>R5499Z151AC</td>
<td>4.390</td>
<td>2.400</td>
<td>0.065</td>
<td>-0.060</td>
</tr>
<tr>
<td>R5499Z152AD</td>
<td>4.390</td>
<td>2.400</td>
<td>0.040</td>
<td>-0.060</td>
</tr>
<tr>
<td>R5499Z153AD</td>
<td>4.390</td>
<td>2.400</td>
<td>0.035</td>
<td>-0.050</td>
</tr>
<tr>
<td>R5499Z154AD</td>
<td>4.425</td>
<td>2.500</td>
<td>0.030</td>
<td>-0.050</td>
</tr>
</tbody>
</table>
R5499Z
NO.EA-388-181119

BLOCK DIAGRAM

PIN DESCRIPTION

R5499Z Pin Description

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>V-</td>
<td>Charger negative Input Pin</td>
</tr>
<tr>
<td>B1</td>
<td>VDD</td>
<td>Power supply pin, the substrate voltage level of the IC.</td>
</tr>
<tr>
<td>C1</td>
<td>VSS</td>
<td>Ground Pin. The ground pin of the IC.</td>
</tr>
<tr>
<td>A2</td>
<td>COUT</td>
<td>Output Pin of Over-charge detection, CMOS output</td>
</tr>
<tr>
<td>B2</td>
<td>NC</td>
<td>No Connection (Open or connect with VSS)</td>
</tr>
<tr>
<td>C2</td>
<td>DOUT</td>
<td>Output Pin of Over-discharge detection, CMOS output</td>
</tr>
</tbody>
</table>
# ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDD</td>
<td>Supply Voltage</td>
<td>−0.3 to 12</td>
<td>V</td>
</tr>
<tr>
<td>V−</td>
<td>V− Pin Input Voltage</td>
<td>VDD −30 to VDD +0.3</td>
<td>V</td>
</tr>
<tr>
<td>V\text{COUT}</td>
<td>COUT Pin Output Voltage</td>
<td>VDD −30 to VDD +0.3</td>
<td>V</td>
</tr>
<tr>
<td>V\text{DOUT}</td>
<td>DOUT Pin Output Voltage</td>
<td>VSS −0.3 to VDD +0.3</td>
<td>V</td>
</tr>
<tr>
<td>P\text{D}</td>
<td>Power Dissipation</td>
<td>150</td>
<td>mW</td>
</tr>
<tr>
<td>Tj</td>
<td>Junction Temperature Range</td>
<td>−40 to 125</td>
<td>°C</td>
</tr>
<tr>
<td>Tstg</td>
<td>Storage Temperature Range</td>
<td>−55 to 125</td>
<td>°C</td>
</tr>
</tbody>
</table>

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages and may degrade the lifetime and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings is not assured.

# RECOMMENDED OPERATING CONDITIONS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>V\text{DD1}</td>
<td>Operating Input Voltage</td>
<td>1.5 to 5.0</td>
<td>V</td>
</tr>
<tr>
<td>Ta</td>
<td>Operating Temperature Range</td>
<td>−40 to 85</td>
<td>°C</td>
</tr>
</tbody>
</table>

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.
### R5499Z Electrical Characteristics

**R5499ZxxxAC/D Electrical Characteristics**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VST</td>
<td>Minimum Operating Voltage for 0V Charging</td>
<td>Voltage Defined as VDD-V-, VDD-VSS = 0V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VDET1</td>
<td>Over-charge Threshold Voltage</td>
<td>R1 = 330Ω, 0°C ≤ Ta ≤ 50°C</td>
<td>VDET1 = 0.012</td>
<td>VDET1 = 0.012</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>VDET1</td>
<td>Output Delay of Over-charge</td>
<td>VDD = 3.6V → VDET1 + 0.05V</td>
<td>0.7</td>
<td>1.0</td>
<td>1.3</td>
<td>s</td>
</tr>
<tr>
<td>tVREL1</td>
<td>Release Delay for VD1</td>
<td>VDD = 4V, V- = 0V → 1V</td>
<td>11</td>
<td>16</td>
<td>21</td>
<td>ms</td>
</tr>
<tr>
<td>VDET2</td>
<td>Over-discharge Threshold</td>
<td>Detect falling edge of supply voltage</td>
<td>VDET2 x 0.975</td>
<td>VDET2 x 1.025</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>tVDET2</td>
<td>Output Delay of Over-discharge</td>
<td>VDD = 3.6V to 2.0V</td>
<td>22.4</td>
<td>32.0</td>
<td>41.6</td>
<td>ms</td>
</tr>
<tr>
<td>tVREL2</td>
<td>Release Delay for VD2</td>
<td>VDD = 3V, V- = 3V to 0V</td>
<td>0.7</td>
<td>1.2</td>
<td>1.7</td>
<td>ms</td>
</tr>
<tr>
<td>VDET3</td>
<td>Excess discharge-current threshold</td>
<td>Detect rising edge of &quot;V-&quot; pin voltage</td>
<td>VDET3 = 0.005</td>
<td>VDET3 = 0.005</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>tVDET3</td>
<td>Output delay of excess discharge-current</td>
<td>VDD = 3.0V, V- = 0V to VDET3 = 0.01V</td>
<td>89.6</td>
<td>128.0</td>
<td>166.4</td>
<td>ms</td>
</tr>
<tr>
<td>tVREL3</td>
<td>Output delay of release from excess discharge-current</td>
<td>VDD = 3.0V, V- = 3V to 0V</td>
<td>0.7</td>
<td>1.2</td>
<td>1.7</td>
<td>ms</td>
</tr>
<tr>
<td>VSHORT</td>
<td>Short Protection Voltage</td>
<td>VDD = 3.0V</td>
<td>VSHORT = 0.05</td>
<td>VSHORT = 0.05</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>tSHORT</td>
<td>Delay Time for Short Protection</td>
<td>VDD = 3.0V, V- = 0V to 0.5V</td>
<td>150</td>
<td>250</td>
<td>350</td>
<td>µs</td>
</tr>
<tr>
<td>RSHORT</td>
<td>Reset Resistance for Excess Current Protection</td>
<td>VDD = 3.6V, V- = 1.0V</td>
<td>20</td>
<td>45</td>
<td>70</td>
<td>kΩ</td>
</tr>
<tr>
<td>VDET4</td>
<td>Excess charge-current threshold</td>
<td>Detect falling edge of &quot;V-&quot; pin voltage</td>
<td>VDET4 = 0.015</td>
<td>VDET4 = 0.015</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>tVDET4</td>
<td>Output delay of excess charge-current</td>
<td>VDD = 3.0V, V- = 0V to -1V</td>
<td>5.6</td>
<td>8.0</td>
<td>10.4</td>
<td>ms</td>
</tr>
<tr>
<td>tVREL4</td>
<td>Output delay of release from excess charge-current</td>
<td>VDD = 3.0V, V- = -1V to 0V</td>
<td>0.7</td>
<td>1.2</td>
<td>1.7</td>
<td>ms</td>
</tr>
<tr>
<td>VDS</td>
<td>Delay Time Shortening Mode Voltage</td>
<td>VDD = 3.6V</td>
<td>VDD = 3.6V</td>
<td>-2.6</td>
<td>-2.0</td>
<td>-1.4</td>
</tr>
<tr>
<td>VOL1</td>
<td>Nch ON-Voltage of COUT</td>
<td>Id = 50µA, VDD = 4.55V</td>
<td>0.4</td>
<td>0.5</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>VOH1</td>
<td>Pch ON-Voltage of COUT</td>
<td>Id = -50µA, VDD = 3.9V</td>
<td>3.4</td>
<td>3.7</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>VOL2</td>
<td>Nch ON-Voltage of DOUT</td>
<td>Id = 50µA, VDD = 1.9V</td>
<td>0.2</td>
<td>0.5</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>VOH2</td>
<td>Pch ON-Voltage of DOUT</td>
<td>Id = -50µA, VDD = 3.9V</td>
<td>3.4</td>
<td>3.7</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>IDD</td>
<td>Supply Current</td>
<td>VDD = 3.9V, V- = 0V</td>
<td>4.0</td>
<td>8.0</td>
<td>16.0</td>
<td>µA</td>
</tr>
<tr>
<td>Istandby</td>
<td>Standby Current</td>
<td>VDD = 2.0V</td>
<td>0.1</td>
<td></td>
<td></td>
<td>µA</td>
</tr>
</tbody>
</table>

**Notes:**

1. Refer to TEST CIRCUITS for details.
2. Considering of variation in process parameters, we compensate for this characteristic related to temperature by laser-trim, however, this specification is guaranteed by design, not mass production tested.

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**R5499Z**

NO.EA-388-181119
Test Circuits

A

B

C

D

E

F

G

H

I

J

K

L
THEORY OF OPERATION

Overcharge Detector (VD1)

The VD1 monitors VDD pin voltage during charge. When the VDD voltage crosses over-charge detector threshold VDET1, the VD1 can sense over-charge and the output of COUT pin becomes “L” and stop charging by turning off the external Nch-MOSFET.

After detecting over-charge, when the voltage of VDD pin is less than over-charge detector threshold, and after disconnecting a charger, VD1 is released. 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 over-charge. Then, the output level of COUT becomes “H” and by turning on the external Nch-MOSFET, the battery charger is ready to work again. In other words, once detecting over-charge, even if the cell voltage would become lower than VDET1, if a charger were being set, recharge is impossible. Therefore, there is no hysteresis for VD1. To judge whether or not load is connected, the excess-discharge current detector is used. In other words, by connecting some load, and reset the over-charge detecting state.

When the Input level of VDD pin is equal or more than over-charge detector threshold, and while a charger is disconnected from the battery pack, if a load is connected to the battery pack, the output level of COUT pin is “L”. However, load current can be drawn through a parasitic diode of an external Nch-MOSFET. Then, when the voltage level of VDD pin becomes lower than over-charge threshold, the output level of COUT pin becomes “H”. Output delay time for over-charge detection and released over-charge is internally fixed respectively.

Although the VDD voltage goes up to a higher level than over-charge detector threshold within the output delay time (Typ. 1.0s), VD1 would not work for detecting over-charge. If the action for VD1 to release is done and the condition returns to the initial one within the output delay time (Typ.16ms), VD1 cannot be released. A level shifter is built in a buffer driver for the COUT pin, therefore, the “L” level is equal to the voltage level of V- pin. The output type of COUT pin is CMOS type. (The Output level is between VDD and V-.)

Overdischarge Detector (VD2)

The VD2 monitors a VDD pin voltage during discharge. When the VDD voltage crosses the over-discharge detector threshold VDET2 from a high level to a lower level than VDET2, the VD2 senses over-discharge and stop discharge by turning off an external Nch-MOSFET.

To reset the VD2 with the DOUT pin level being “H” again after detecting over-discharge, if VDD voltage is equal or less than over-charge detector threshold, a charge current flows through a parasitic diode of the external Nch MOSFET. After that, when VDD voltage is more than over-discharge threshold, DOUT 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 VDD level is more than over-discharge detector threshold, the output level of DOUT becomes “H” immediately.

When a cell voltage is equal to 0V, connecting a charger to the battery pack makes COUT 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 (V_{ST}) for 0V charge
An output delay for over-discharge detection is fixed internally. (Typ. 32ms) Although the voltage of V_{DD} becomes equal or less than over-discharge detector threshold and if it becomes higher than over-discharge detector threshold within output delay time, over-discharge detector does not work. Output delay time for release from over-discharge is also set internally. (Typ. 1.2ms)
After detecting over-discharge by VD2, supply current would decrease, (V_{DD}=2.0V, Max. 0.1\mu{A}.) because all circuits are halted and being standby.
The output type of DOUT pin is CMOS type and its output level is in between V_{DD} and V_{SS}.

**Excess Discharge Current 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 equal or more than the excess discharge current threshold and less than the short detector threshold, the excess discharge current detector works. When the voltage level of V- pin becomes equal or more than short detector threshold voltage, the short circuit protector works and the output level of DOUT 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 excess discharge current detector is internally fixed at 128ms typical. Although the voltage of V- pin becomes equal or more than the excess discharge current threshold voltage and less than short detector threshold, if it becomes less than the excess current detector threshold voltage within the output delay time, the excess current detector does not work. Output delay time for release from excess discharge current is also set internally (Typ. 1.2ms). In terms of short circuit protector, output delay time is typically 250\mu{s}. The V- pin has a built-in pull down resistor, Typ. 45k\Omega connected to the V_{SS} pin.
After an excess discharge current or short circuit protection is detected, by removing a cause of excess current or external short circuit, the voltage level of V- is pulled down through the resistor for release from excess current to the V_{SS} level. Then, when the voltage level of V- pin becomes equal or less than the excess current threshold voltage, both protection circuits are released automatically. Resistor for release from excess discharge current is active when excess discharge current 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 excess discharge current is necessarily set shorter than output delay time for over-discharge. Therefore, if excess discharge current is detected, and at the same time, VDD pin voltage becomes lower than over-discharge detector threshold level, excess discharge current detector is predominant. By disconnecting load from the battery pack, the battery pack is automatically released from excess current status.
Excess Charge-current 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 with an inappropriate charger, excess current flows, and then the voltage of V- pin becomes equal or less than excess charge-current detector threshold. Then, the output of \( C_{OUT} \) becomes "L", and protects against flowing excess current in the circuit by turning off the external Nch MOSFET. Output delay of excess charge current is internally fixed. (Typ. 8ms) Even the voltage level of V- pin becomes equal or lower than excess charge-current detector threshold, if the voltage becomes higher than the VD4 threshold within the set delay time, the excess charge-current state is not detected. Output delay time for release from excess charge current is also set internally. (Typ. 1.2ms)
VD4 can be released with disconnecting a charger.

Delay Shortening (DS)
Output delay time of over-charge and over-discharge can be shorter than those setting values by forcing equal or lower than the test shortening mode voltage (Typ. -2.0V) to V- pin.
Timing Chart

Over-charge and Excess Charge Current

Connection of Charger
Connection of Load
Connection of Charger
Connection of Load
Charge Over-current
Charger "OPEN"
Connection of Load

VDD

VDET1

VDD

VDET3

VSS

VDET4

VDD

VDET1

VDD

VREL1

VREL1

VREL4

VREL4

Charge Current

Charge/Discharge Current

Discharge Current
Over-discharge, Excess Discharge Current, and Short-circuit
APPLICATION INFORMATION

Cautions in selecting external components

- R1 and C1 stabilize a supply voltage to the R5499Z. A recommended R1 value is less than 1kΩ. A large value of R1 makes detection voltage shift higher because of conduction current flowed in the R5499Z. Further, to stabilize the operation of R5499Z, use the C1 with the value of 0.01μF or more.

- R1 and R2 can operate also as parts for current limit circuit against reverse charge or applying a charger with excess charging voltage to the R5499Z, battery pack. While small value of R1 and R2 may cause over power dissipation rating of the R5499Z, therefore a total of “R1+R2” should be 1kΩ or more. Besides, if large value of R2 is set, release from over-discharge by connecting a charger might not be possible. Recommended R2 value is equal or less than 10kΩ.

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

- Over-voltage and the over current beyond the absolute maximum rating should not be forced to the protection IC and external components. Although the short protection circuit is built in the IC, if the positive terminal and the negative terminal of the battery pack are short, during the delay time of short limit detector, large current flows through the FET. Select an appropriate FET with large enough current capacity to prevent the IC from burning damage.
WLCSP-6-P4 Package Dimensions (Unit: mm)
## Visual Inspection Criteria

<table>
<thead>
<tr>
<th>No.</th>
<th>Inspection Items</th>
<th>Inspection Criteria</th>
<th>Figure</th>
</tr>
</thead>
</table>
| 1   | Package chipping       | A ≥ 0.2mm is rejected  
B ≥ 0.2mm is rejected  
C ≥ 0.2mm is rejected  
And, Package chipping to Si surface and to bump is rejected. |        |
| 2   | Si surface chipping    | A ≥ 0.2mm is rejected  
B ≥ 0.2mm is rejected  
C ≥ 0.2mm is rejected  
But, even if A ≥ 0.2mm, B ≤ 0.1mm is acceptable. |        |
| 3   | No bump                | No bump is rejected.                                                               |        |
| 4   | Marking miss           | To reject incorrect marking, such as another product name marking or another lot No. marking. |        |
| 5   | No marking             | To reject no marking on the package.                                               |        |
| 6   | Reverse direction of marking | To reject reverse direction of marking character.                        |        |
| 7   | Defective marking      | To reject unreadable marking.  
(Microscope: X15/ White LED/ Viewed from vertical direction)                      |        |
| 8   | Scratch                | To reject unreadable marking character by scratch.  
(Microscope: X15/ White LED/ Viewed from vertical direction)                      |        |
| 9   | Stain and Foreign material | To reject unreadable marking character by stain and foreign material.  
(Microscope: X15/ White LED/ Viewed from vertical direction)                      |        |
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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