RICOH

R5542Z Series

6 A Low ON Resistance Nch Load Switch IC with Voltage Detector

OUTLINE

The R5542Z is a Nch. load switch IC with a voltage detector. The R5542Z is an ideal load switch IC for supplying the power from the battery to the load circuit. A built-in Nch. driver transistor with typically 9 mΩ ON resistance allows the R5542Z to provide a low dropout voltage and prevents the reverse current during shutdown mode. Internally, the R5542Z consists of an internal voltage step-up circuit, a soft-start circuit, a chip enable circuit and a UVLO circuit. The R5542Z is offered in an ultra-small WLCSP-12-P3 package which can achieve the smallest possible footprint solution on boards where area is limited.

FEATURES

Load Switch Section
- Input Voltage Range ·············································· 2.3 V to 5.5 V
- Output Current······················································· DC Max. 6 A
- Output Pulsed Current··········································· Max. 12 A (Pulsed at 1 ms, 10% Duty Cycle)
- Switch ON Resistance··········································· 9 mΩ (VIN = 3.0 V, IOUT = 300 mA)
- Reverse Current Blocking (RCB) during shutdown mode
- Soft-start Function

Voltage Detector Section
- Supply Current······················································· Typ. 1.0 µA (VDDI = 2.0 V)
- Operating Voltage Range········································· 1.2 V to 5.5 V (Ta = 25°C)
- Detector Threshold Range········································· 2.0 V to 5.0 V (0.1 V steps)
- Detector Threshold Accuracy······································ ±2.0%
- Detector Threshold Temperature Coefficient·················· Typ. ±100 ppm/°C
- Output Type·························································· CMOS
- Package································································· WLCSP-12-P3

APPLICATIONS
- Smart Phones, Tablet PCs
- Storage, Portable Devices
**Selection Guide**

The detector threshold is a user-selectable option.

<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>R5542Zxx2B-E2-F</td>
<td>WLCSP-12-P3</td>
<td>4,000 pcs</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

xx: Specify the detector threshold within the range of 2.0 V (20) to 5.0 V (50) in 0.1 V steps.

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**BLOCK DIAGRAMS**

![R5542Zxx2B Block Diagram](image)
# PIN DESCRIPTIONS

![Top View](image1.png)

![Bottom View](image2.png)

**R5542Z (WLCSP-12-P3) Pin Configurations**

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Symbol</th>
<th>Pin Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1, B1, B2, C1</td>
<td>OUT</td>
<td>Load Switch Output Pin</td>
</tr>
<tr>
<td>A3, B3, C2, C3</td>
<td>IN</td>
<td>Load Switch Input Pin</td>
</tr>
<tr>
<td>A2</td>
<td>LCE</td>
<td>Load Switch Control Enable Pin</td>
</tr>
<tr>
<td>D1</td>
<td>GND</td>
<td>Ground Pin</td>
</tr>
<tr>
<td>D2</td>
<td>VDO</td>
<td>Voltage Detector Output Pin</td>
</tr>
<tr>
<td>D3</td>
<td>VDI</td>
<td>Voltage Detector Input Pin</td>
</tr>
</tbody>
</table>
## ABSOLUTE MAXIMUM RATINGS

### Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Item</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{IN}$</td>
<td>Load Switch Input Voltage</td>
<td>$-0.3$ to $6.0$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{OUT}$</td>
<td>Load Switch Output Voltage</td>
<td>$-0.3$ to $V_{IN} + 0.3$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{LCE}$</td>
<td>LCE Pin Voltage</td>
<td>$-0.3$ to $6.0$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{VDI}$</td>
<td>VDI Pin Voltage</td>
<td>$-0.3$ to $6.0$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{VDD}$</td>
<td>VDO Pin Voltage</td>
<td>$-0.3$ to $V_{VDI} + 0.3$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{PP}$</td>
<td>Pin to Pin Voltage</td>
<td>$-0.3$ to $6.0$</td>
<td>V</td>
</tr>
<tr>
<td>$I_{OUT}$</td>
<td>Load Switch Output Current</td>
<td>$6.0$</td>
<td>A</td>
</tr>
<tr>
<td>$I_{PULSE}$</td>
<td>Load Switch Output Pulsed Current (Pulsed at 1ms, 10% Duty Cycle)</td>
<td>$12.0$</td>
<td>A</td>
</tr>
<tr>
<td>$P_{D}$</td>
<td>Power Dissipation(\textsuperscript{1}) (WLCSP-12-P3, JEDEC STD.51-9)</td>
<td>$1000$</td>
<td>mW</td>
</tr>
<tr>
<td>$T_{j}$</td>
<td>Junction Temperature Range</td>
<td>$-40$ to $125$</td>
<td>°C</td>
</tr>
<tr>
<td>$T_{stg}$</td>
<td>Storage Temperature Range</td>
<td>$-55$ to $125$</td>
<td>°C</td>
</tr>
</tbody>
</table>

### ABSOLUTE MAXIMUM RATINGS

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 are not assured.

### RECOMMENDED OPERATING CONDITIONS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Item</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{IN}$</td>
<td>Input Voltage</td>
<td>$2.3$ to $5.5$</td>
<td>V</td>
</tr>
<tr>
<td>$T_{a}$</td>
<td>Operating Temperature Range</td>
<td>$-40$ to $85$</td>
<td>°C</td>
</tr>
</tbody>
</table>

### 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.

\(\textsuperscript{1}\) Refer to POWER DISSIPATION in SUPPLEMENTARY ITEMS for detail information.
ELECTRICAL CHARACTERISTICS

$V_{IN} = 2.3\, \text{V to 5.5\, \text{V}}, I_{OUT} = 1\, \text{mA}, C_{IN} = 1\, \mu\text{F}, C_{OUT} = \text{None},$ unless otherwise noted.

The specifications surrounded by $\underline{\quad}$ are guaranteed by design engineering at $−40°C \leq T_a \leq 85°C$.

### Electrical Characteristics

#### Symbol | Item | Conditions | Min. | Typ. | Max.  | Unit
---|---|---|---|---|---|---
$I_{Q}$ | Quiescent Current | $I_{OUT} = 0\, \text{mA}$ | 10 | 30 | $\mu\text{A}$
$I_{Q(OFF)}$ | Standby Current | $V_{LCE} = 0\, \text{V}, V_{IN} = 5.5\, \text{V}, V_{OUT} = \text{OPEN}$ | 1 | $\mu\text{A}$
$I_{SD}$ | Shutdown Current | $V_{LCE} = 0\, \text{V}, V_{IN} = 5.5\, \text{V}, V_{OUT} = \text{GND}$ | 1 | $\mu\text{A}$
$R_{ON}$ | Switch ON Resistance | $I_{OUT} = 300\, \text{mA}, V_{IN} = 3\, \text{V}$ | 9 | $\text{m}\Omega$
$V_{IH}$ | LCE Pin Input Voltage, high | $V_{IN} = 5.0\, \text{V}$ | 1.0 | | $\text{V}$
$V_{IL}$ | LCE Pin Input Voltage, low | $V_{IN} = 5.0\, \text{V}$ | 0.4 | | $\text{V}$
$R_{LCE-PD}$ | LCE Pull-down Resistance | $V_{IN} = 2.3\, \text{V to 5.5\, \text{V}}$ | 5.5 | | $\text{M}\Omega$
$I_{LCE}$ | LCE Input Leakage Current | $V_{IN} = 2.3\, \text{V to 5.5\, \text{V}}, V_{LCE} = \text{GND}$ | $–1$ | 1 | $\mu\text{A}$
$t_{ON}$ | Turn-on Time | $V_{IN} = 3\, \text{V}, R_{L} = 50\, \Omega, C_{OUT} = 10\, \mu\text{F}$ | 2 | | $\text{ms}$
$UVLO$ | Undervoltage Lockout Voltage | &nbsp; | 2.0 | 2.3 | $\text{V}$

#### Voltage Detector Section

| Symbol | Item | Conditions | Min. | Typ. | Max.  | Unit |
---|---|---|---|---|---|---
$-V_{DET}$ | Detector Threshold & (2) | $V_{VDI}$ falling | $-V_{SET} \times 0.98$ | $-V_{SET} \times 1.02$ | | $\text{V}$
$V_{HYS}$ | Detector Threshold Hysteresis | | $-V_{SET} \times 0.03$ | $-V_{SET} \times 0.05$ | $-V_{SET} \times 0.07$ | | $\text{V}$
$I_{SS}$ | Supply Current | $2.0\, \text{V} < -V_{SET}, V_{VDI} = 2.0\, \text{V}$ | 1.0 | | | $\mu\text{A}$
| | | $2.0\, \text{V} \leq -V_{SET} \leq 5.0\, \text{V}$ | $V_{VDI} = -V_{SET} -0.16\, \text{V}$ | 3.3 | | $\mu\text{A}$
| | | | | | | $V_{VDI} = -V_{SET} +0.50\, \text{V}$ | 3.4 | |
$V_{VDI}$ | Voltage Detector Operating Voltage | $T_a = 25°C$ | 1.2(3) | 5.5 | | $\text{V}$
| | | $-40°C \leq T_a \leq 85°C$ | 1.3(3) | | | $\text{V}$
$I_{VDO}$ | Output Current (Nch. Driver Output Pin) | $2.0 \leq -V_{SET} \leq 5.0\, \text{V}$ | $V_{DS} = 0.5\, \text{V}, V_{VDI} = 1.5\, \text{V}$ | 1.0 | 2.0 | | $\text{mA}$
| | | | | | | $V_{DS} = -2.1\, \text{V}, V_{VDI} = 5.5\, \text{V}$ | 1.0 | 2.5 | |
$I_{RLH}$ | Release Output Delay Time & (4) | | | | 100 | $\mu\text{s}$ |
$\Delta V_{DET}$ | Detector Threshold Temperature Coefficient | $-40°C \leq T_a \leq 85°C$ | | | $\pm 100$ | $\text{ppm/°C}$ |

All test items listed under Electrical Characteristics are done under the pulse load condition ($T_j \approx T_a = 25°C$) except Detector Threshold Temperature Coefficient.

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(1) The UVLO detector threshold and the UVLO release voltage are between the min and max of UVLO with Typ. 0.02 V hysteresis.

(2) $-V_{SET}$ is defined as an actual detector threshold and $-V_{SET}$ is defined as a preset detector threshold.

(3) Each minimum value is the value of input voltage when the output voltage is maintained at 0.1 V or less.

(4) Refer to “Release Output Delay Time” for details.
OPERATING DESCRIPTIONS

Voltage Detector Section

R5542Zxx2B Block Diagram

**Step** | 1 | 2 | 3 | 4 | 5
---|---|---|---|---|---
Comparator (-) Pin Input Voltage | I | II | II | II | I
Comparator Output | L | H | Indefinite | H | L
Tr.1 Output | OFF | ON | Indefinite | ON | OFF
Output Tr. | Pch | ON | OFF | Indefinite | OFF | ON
| Nch | OFF | ON | Indefinite | ON | OFF

**Operation Diagram**

1. The $V_{VDD}$ voltage is equalized to the $V_{VDI}$ voltage.
2. The $V_{VDI}$ voltage drops to the detector threshold (A point) which means $V_{ref} \geq V_{VDI} \times (R_b + R_c) / (R_a + R_b + R_c)$. The comparator output shifts from “L” to “H” voltage and the VDO pin voltage will be equalized to the GND voltage.
3. If the $V_{VDI}$ voltage is lower than the minimum operating voltage, the $V_{VDD}$ voltage becomes unstable.
4. The VDO pin voltage is equalized to the GND voltage.
5. The $V_{VDI}$ voltage becomes higher than the release voltage (B point) which means $V_{ref} < V_{VDI} \times R_b / (R_a + R_b)$, and the comparator output shifts from “H” to “L” voltage, and the VDO pin voltage is equalized to the $V_{VDI}$ voltage.

Note: The difference between a released voltage and a detector threshold voltage is a detector threshold hysteresis.
Timing Chart

R5542Zxx2B Load Switch Section

R5542Zxx2B Voltage Detector Section

Release Output Delay Time ($t_{PLH}$)
Release output delay time starts when the $V_{DOI}$ voltage is shifted from 1.3V to $+V_{DET} + 1.0V$ and ends when the output voltage reaches $(+V_{DET} + 1.0V) / 2$. 

R5542Zxx2B Release Output Delay Time
APPLICATION INFORMATION

Typical Application Circuit

R5542Z does not require any bypass capacitor between IN and GND. However, connecting 1μF or more capacitor between IN and GND may improve the performance against noise. To make delay time from detect input voltage drop to load switch turn off, connect resistor and capacitor between VDO and LCE.

If the ramp rate of "IN" is faster than 50mV/μs, some voltage glitch may appear on "OUT". The glitch level depends on the capacitance connected to "OUT" and the ramp rate of "IN".
TYPICAL CHARACTERISTICS

Typical Characteristics are intended to be used as reference data, they are not guaranteed.

1) ON Resistance vs. Temperature / Input Voltage
   $V_{IN} = 3.0V$ / $I_{OUT} = 500mA$

2) Rising Time vs. Temperature / Input Voltage
   $V_{IN} = 3.0V$ / $R_{LOAD} = 50\Omega$ / $C_{OUT} = 10\mu F$

3) SW Supply Current vs. Temperature / Input Voltage
   $[V_{IN} = 0V \rightarrow 6.0V]$
4) SW Standby Current vs. Temperature / Input Voltage

![Graph of Standby Current vs. Temperature / Input Voltage for VIN 3.0V and 5.0V](image)

5) SW Shutdown Current vs. Temperature / Input Voltage

![Graph of Shutdown Current vs. Temperature / Input Voltage for VIN 3.0V and 5.0V](image)

6) $V_{IH}$ vs. Temperature / Input Voltage

![Graph of $V_{IH}$ vs. Temperature / Input Voltage for VIN 3.0V and 5.0V](image)
7) $V_{IL}$ vs. Temperature / Input Voltage

8) LCE Pull-down Resistance vs. Temperature

9) UVLO Detection/Release Voltage vs. Temperature

10) VD Detection Voltage vs. Temperature
11) $V_{HYS}$ vs. Temperature

12) VD Supply Current vs. Temperature

13) Nch Dr. Output Current vs. Temperature

14) Pch Dr. Output Current vs. Temperature

15) Release Output Delay vs. Temperature
16) VD Transient
Set-$V_{DET} = 2.0$ V
$V_{DI} \text{ "L"} = 2.01$ V
$5.5V \leftrightarrow -V_{DET} + 10$ mV

$V_{DI} \text{ "L"} = 1.99$ V
$5.5V \leftrightarrow -V_{DET} - 10$ mV

17) VD Glitch

Detector Threshold -$V_{DET}$ [V] vs. VDI Voltage Low Level Period [μs] 

(V$_{DET} = 2.0$ V / $Ta = 25^\circ$C)
18) SW Inrush Current
$V_{IN} = 3.0\text{V}$ / $R_{LOAD} = 50\Omega$

- $C_{OUT} = 0.1\mu\text{F}$
- $C_{OUT} = 1.0\mu\text{F}$
- $C_{OUT} = 10\mu\text{F}$
- $C_{OUT} = 100\mu\text{F}$
- $C_{OUT} = 100\mu\text{F} \times 2$
- $C_{OUT} = 100\mu\text{F} \times 3$
19) VD-SW Reset

\[ \text{V}_{\text{IN}} = \text{V}_{\text{DI}} = 3.8\text{V} < 2.8\text{V} / C_1 = 0.01\mu\text{F} \]

\[ \text{V}_{\text{IN}} = \text{V}_{\text{DI}} = 3.8\text{V} < 2.8\text{V} / C_1 = 1.0\mu\text{F} \]
20) VD Supply Current vs. Input Voltage

- $V_{DI} = 0\, \text{V} \rightarrow 6.0\, \text{V}$
- $V_{DI} = 6.0\, \text{V} \rightarrow 0\, \text{V}$

For each case, the graphs show the relationship between $V_D$ supply current [μA] and $V_{DI}$ input voltage [V] for different temperatures $(T_a = -40^\circ\text{C}, 25^\circ\text{C}, 85^\circ\text{C})$.

- $V_{DET} = 2.0\, \text{V}$
- $V_{DET} = 5.0\, \text{V}$
The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following conditions are used in this measurement.

**Measurement Conditions**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>Mounting on Board (Wind Velocity = 0 m/s)</td>
</tr>
<tr>
<td>Board Material</td>
<td>Glass Cloth Epoxy Plastic (Four-Layer Board)</td>
</tr>
<tr>
<td>Board Dimensions</td>
<td>101.5 mm x 114.5 mm x 1.6 mm</td>
</tr>
<tr>
<td>Copper Ratio</td>
<td>Outer Layers (First and Fourth Layers): Approx. 60%</td>
</tr>
<tr>
<td></td>
<td>Inner Layers (Second and Third Layers): Approx. 100%</td>
</tr>
</tbody>
</table>

**Measurement Result**

*(Ta = 25°C, Tjmax = 125°C)*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Dissipation</td>
<td>1000 mW</td>
</tr>
<tr>
<td>Thermal Resistance</td>
<td>θja = (125 − 25°C) / 1.0 W  = 100 °C/W</td>
</tr>
</tbody>
</table>

**Power Dissipation vs. Ambient Temperature**

**Measurement Board Pattern**

![Diagram of JEDEC STD. 51-9 Test Land Pattern with Power Dissipation vs. Ambient Temperature graph and IC Mount Area (mm)]
WLCSP-12-P3 Package Dimensions (Unit: mm)
<table>
<thead>
<tr>
<th>No.</th>
<th>Inspection Items</th>
<th>Inspection Criteria</th>
<th>Figure</th>
</tr>
</thead>
</table>
| 1   | Package chipping        | A \geq 0.2mm is rejected  
B \geq 0.2mm is rejected  
C \geq 0.2mm is rejected  
And, Package chipping to Si surface and to bump is rejected. | ![Diagram](image1.png) |
| 2   | Si surface chipping     | A \geq 0.2mm is rejected  
B \geq 0.2mm is rejected  
C \geq 0.2mm is rejected  
But, even if A \geq 0.2mm, B \leq 0.1mm is acceptable. | ![Diagram](image2.png) |
| 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)                       |        |
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3. Please be sure to take a safety measure (overcurrent protection circuit etc.) into account for the product.

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Halogen Free

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