The S-8201 series are lithium-ion/lithium polymer rechargeable battery protection ICs incorporating high-accuracy voltage detection circuit and delay circuit. The S-8201 series are suitable for protection of single-cell lithium ion/lithium polymer battery packs from overcharge, overdischarge and overcurrent.

### Features

1. **Internal high accuracy voltage detection circuit**
   - **Overcharge detection voltage**: 3.9 V to 4.4 V (5 mV step)  
     Accuracy: ±25 mV (+25°C) and ±30 mV (-5°C to +55°C)
   - **Overcharge release voltage**: 3.8 V to 4.4 V  
     Accuracy: ±50 mV
   - **Overdischarge detection voltage**: 2.0 V to 3.0 V (10 mV step)  
     Accuracy: ±50 mV
   - **Overdischarge release voltage**: 2.0 V to 3.4 V  
     Accuracy: ±100 mV
   - **Overcurrent 1 detection voltage**: 0.05 V to 0.3 V (10 mV step)  
     Accuracy: ±15 mV
   - **Overcurrent 2 detection voltage**: 0.5 V (fixed)  
     Accuracy: ±100 mV

2. **High voltage device is used for charger connection pins**
   - VM and CO pins: absolute maximum rating = 28 V

3. **Delay times (overcharge: tCU, overdischarge: tDL, overcurrent 1: tOV1, overcurrent 2: tOV2) are generated by an internal circuit. No external capacitor is necessary.**
   Accuracy: ±20%

4. **The overcharge timer reset delay time (7 ms to 40 ms) is generated by an internal circuit only. No external capacitor is necessary.**

5. **Three-step overcurrent detection circuit is included. (overcurrent 1, overcurrent 2, and load short-circuiting)**

6. **Either charge function or charge inhibition function for 0V battery can be selected.**

7. **Charger detection function and abnormal charge current detection function**
   - The overdischarge hysteresis is released by detecting negative voltage at the VM pin (-0.7 V typ.).
     (Charger detection function)
   - When the output voltage of the DO pin is high and the voltage at the VM pin is equal to or lower than the charger detection voltage (-0.7 V typ.), the output voltage of the CO pin goes low.
     (Abnormal charge current detection function)

8. **Low current consumption**
   - **Operation**: 3.5 µA typ., 7.0 µA max.
   - **Power-down**: 0.1 µA max.

9. **Wide operating temperature range:** -40°C to +85°C

10. **Small package**: 6-Pin SOT-23-6 6-Pin SNB(B)

### Applications

- Lithium-ion rechargeable battery packs
- Lithium polymer rechargeable battery packs

### Package

- 6-Pin SOT-23-6 (PKG drawing code: MP006-A)
- 6-Pin SNB(B) (PKG drawing code: BD006-A)
**Block Diagram**

![Block Diagram](image)

Note: Diodes in the figure are parasitic diodes.

*Figure 1 Block Diagram*
## Selection Guide

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Overcharge detection voltage</th>
<th>Overcharge release voltage</th>
<th>Overdischarge detection voltage</th>
<th>Overdischarge release voltage</th>
<th>Overcurrent 1 detection voltage</th>
<th>0 V battery charge function</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-8201AAABD-M5A-TF</td>
<td>4.3 V</td>
<td>4.1 V</td>
<td>2.3 V</td>
<td>2.3 V</td>
<td>0.13 V</td>
<td>Yes</td>
</tr>
<tr>
<td>S-8201AABBBD-M5B-TF</td>
<td>4.305 V</td>
<td>4.005 V</td>
<td>2.3 V</td>
<td>2.9 V</td>
<td>0.1 V</td>
<td>Yes</td>
</tr>
<tr>
<td>S-8201AACBD-M5C-TF</td>
<td>4.295 V</td>
<td>3.995 V</td>
<td>2.3 V</td>
<td>2.9 V</td>
<td>0.15 V</td>
<td>None</td>
</tr>
<tr>
<td>S-8201AADBD-M5D-TF</td>
<td>4.325 V</td>
<td>4.075 V</td>
<td>2.5 V</td>
<td>2.9 V</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>S-8201AAEBD-M5E-TF</td>
<td>4.350 V</td>
<td>4.150 V</td>
<td>2.3 V</td>
<td>3.0 V</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>S-8201AABFD-M5F-TF</td>
<td>4.350 V</td>
<td>4.150 V</td>
<td>2.3 V</td>
<td>3.0 V</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Product Name

S-8201 A  xx xx  xxx -xx

- **Tape direction**
  - T2 : SOT-23-6
  - TF : 6-Pin SNB(B)

- **Product code**
  - MD : SOT-23-6
  - BD : 6-Pin SNB(B)

- **Package code**
  - MD : SOT-23-6
  - BD : 6-Pin SNB(B)

- **Serial code**

It is possible to change the detection voltages of the product other than above. The delay times can also be changed within the range listed below. For details, please contact our sales office.

<table>
<thead>
<tr>
<th>Delay time</th>
<th>Symbol</th>
<th>Selection range</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overcharge detection delay time</td>
<td>tCU</td>
<td>0.15 s</td>
<td>1.2 s</td>
</tr>
<tr>
<td>Overdischarge detection delay time</td>
<td>tDL</td>
<td>37.5 ms</td>
<td>150 ms</td>
</tr>
<tr>
<td>Overcurrent 1 detection delay time</td>
<td>tOV1</td>
<td>4.5 ms</td>
<td>9 ms</td>
</tr>
</tbody>
</table>

* Values surrounded by bold lines are used in standard products.
### Pin Assignment

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DO</td>
<td>FET gate control pin for discharge (CMOS output)</td>
</tr>
<tr>
<td>2</td>
<td>VM</td>
<td>Voltage detection pin between VM and VSS (Overcurrent detection pin)</td>
</tr>
<tr>
<td>3</td>
<td>CO</td>
<td>FET gate control pin for charge (CMOS output)</td>
</tr>
<tr>
<td>4</td>
<td>DP</td>
<td>Test pin for delay time acceleration</td>
</tr>
<tr>
<td>5</td>
<td>VDD</td>
<td>Positive power input pin</td>
</tr>
<tr>
<td>6</td>
<td>VSS</td>
<td>Negative power input pin</td>
</tr>
</tbody>
</table>

#### Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Applied pin</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input voltage between VDD and VSS</td>
<td>V_{DS}</td>
<td>VDD</td>
<td>V_{SS} -0.3 to V_{SS} +12</td>
<td>V</td>
</tr>
<tr>
<td>Input pin voltage for DP</td>
<td>V_{DP}</td>
<td>DP</td>
<td>V_{SS} -0.3 to V_{DD} +0.3</td>
<td>V</td>
</tr>
<tr>
<td>Input pin voltage for VM</td>
<td>V_{VM}</td>
<td>VM</td>
<td>V_{DD} -28 to V_{DD} +0.3</td>
<td>V</td>
</tr>
<tr>
<td>Output pin voltage for CO</td>
<td>V_{CO}</td>
<td>CO</td>
<td>V_{VM} -0.3 to V_{DD} +0.3</td>
<td>V</td>
</tr>
<tr>
<td>Output pin voltage for DO</td>
<td>V_{DO}</td>
<td>DO</td>
<td>V_{SS} -0.3 to V_{DD} +0.3</td>
<td>V</td>
</tr>
<tr>
<td>Power</td>
<td>P_{D}</td>
<td>—</td>
<td>250</td>
<td>mW</td>
</tr>
<tr>
<td>dissipation</td>
<td>P_{D}</td>
<td>—</td>
<td>90</td>
<td>mW</td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>T_{opr}</td>
<td>—</td>
<td>-40 to +85</td>
<td>°C</td>
</tr>
<tr>
<td>Storage temperature range</td>
<td>T_{stg}</td>
<td>—</td>
<td>-55 to +125</td>
<td>°C</td>
</tr>
</tbody>
</table>

Caution: The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.

*1. Do not apply pulse-like noise of μs order exceeding the above input voltage (V_{SS} + 12 V). The noise causes damage to the IC.
### Electrical Characteristics (1) Except detection delay time

(\(Ta = 25^\circ C\) unless otherwise specified)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Remark</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
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<tbody>
<tr>
<td>DETECTION VOLTAGE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overcharge detection voltage</td>
<td>(V_{CU})</td>
<td>1</td>
<td>–</td>
<td>(V_{CU} -0.025)</td>
<td>(V_{CU} +0.025)</td>
<td>(V_{CU} +0.03)</td>
<td></td>
</tr>
<tr>
<td>Overcharge release voltage</td>
<td>(V_{CL})</td>
<td>1</td>
<td>–</td>
<td>(V_{CL} -0.05)</td>
<td>(V_{CL} +0.05)</td>
<td>(V_{CL} +0.03)</td>
<td></td>
</tr>
<tr>
<td>Overdischarge detection voltage</td>
<td>(V_{DL})</td>
<td>2</td>
<td>–</td>
<td>(V_{DL} -0.05)</td>
<td>(V_{DL} +0.05)</td>
<td>(V_{DL} +0.03)</td>
<td></td>
</tr>
<tr>
<td>Overdischarge release voltage</td>
<td>(V_{DU})</td>
<td>2</td>
<td>–</td>
<td>(V_{DU} -0.1)</td>
<td>(V_{DU} +0.1)</td>
<td>(V_{DU} +0.03)</td>
<td></td>
</tr>
<tr>
<td>Overcurrent 1 detection voltage</td>
<td>(V_{O1})</td>
<td>3</td>
<td>–</td>
<td>(V_{O1} -0.015)</td>
<td>(V_{O1} +0.015)</td>
<td>(V_{O1} +0.03)</td>
<td></td>
</tr>
<tr>
<td>Overcurrent 2 detection voltage</td>
<td>(V_{O2})</td>
<td>3</td>
<td>–</td>
<td>0.4</td>
<td>0.6</td>
<td>V</td>
<td>2</td>
</tr>
<tr>
<td>Load short-circuiting detection voltage</td>
<td>(V_{SHORT})</td>
<td>3</td>
<td>–</td>
<td>0.9</td>
<td>1.2</td>
<td>1.5</td>
<td>V</td>
</tr>
<tr>
<td>Charger detection voltage</td>
<td>(V_{CHA})</td>
<td>4</td>
<td>–</td>
<td>-1.0</td>
<td>-0.7</td>
<td>-0.4</td>
<td>V</td>
</tr>
<tr>
<td>INPUT VOLTAGE, OPERATION VOLTAGE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation voltage between VDD and VSS</td>
<td>(V_{DSOP1})</td>
<td>–</td>
<td>–</td>
<td>1.5</td>
<td>–</td>
<td>8</td>
<td>V</td>
</tr>
<tr>
<td>Operation voltage between VDD and VM</td>
<td>(V_{DSOP2})</td>
<td>–</td>
<td>–</td>
<td>1.5</td>
<td>–</td>
<td>28</td>
<td>V</td>
</tr>
<tr>
<td>CURRENT CONSUMPTION</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current consumption in normal operation</td>
<td>(I_{OPN})</td>
<td>5</td>
<td>(V_{DD} = 3.5 \text{ V}, V_{VM} = 0 \text{ V})</td>
<td>1.0</td>
<td>3.5</td>
<td>7.0</td>
<td>(\mu\text{A})</td>
</tr>
<tr>
<td>Current consumption at power down</td>
<td>(I_{PDN})</td>
<td>5</td>
<td>(V_{DD} = 1.5 \text{ V})</td>
<td>–</td>
<td>–</td>
<td>0.1</td>
<td>(\mu\text{A})</td>
</tr>
<tr>
<td>OUTPUT RESISTANCE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO pin H resistance</td>
<td>(R_{COH})</td>
<td>7</td>
<td>(V_{DD} = 3.0 \text{ V}, V_{CM} = 3.5 \text{ V}, V_{VM} = 0 \text{ V})</td>
<td>2.5</td>
<td>5</td>
<td>10</td>
<td>k(\Omega)</td>
</tr>
<tr>
<td>CO pin L resistance</td>
<td>(R_{COL})</td>
<td>7</td>
<td>(V_{DD} = 0.5 \text{ V}, V_{CM} = 4.5 \text{ V}, V_{VM} = 0 \text{ V})</td>
<td>2.5</td>
<td>5</td>
<td>10</td>
<td>k(\Omega)</td>
</tr>
<tr>
<td>DO pin H resistance</td>
<td>(R_{DOH})</td>
<td>8</td>
<td>(V_{DD} = 3.0 \text{ V}, V_{CM} = 3.5 \text{ V}, V_{VM} = 0 \text{ V})</td>
<td>2.5</td>
<td>5</td>
<td>10</td>
<td>k(\Omega)</td>
</tr>
<tr>
<td>DO pin L resistance</td>
<td>(R_{DOL})</td>
<td>8</td>
<td>(V_{DD} = 0.5 \text{ V}, V_{CM} = 1.8 \text{ V})</td>
<td>2.5</td>
<td>5</td>
<td>10</td>
<td>k(\Omega)</td>
</tr>
<tr>
<td>VM INTERNAL RESISTANCE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal resistance between VM and VDD</td>
<td>(R_{VM})</td>
<td>6</td>
<td>(V_{DD} = 1.8 \text{ V}, V_{CM} = 0 \text{ V})</td>
<td>100</td>
<td>300</td>
<td>900</td>
<td>k(\Omega)</td>
</tr>
<tr>
<td>Internal resistance between VM and VSS</td>
<td>(R_{VSS})</td>
<td>6</td>
<td>(V_{DD} = 3.5 \text{ V}, V_{CM} = 1.0 \text{ V})</td>
<td>10</td>
<td>20</td>
<td>40</td>
<td>k(\Omega)</td>
</tr>
<tr>
<td>0V BATTERY CHARGING FUNCTION</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 V battery charge starting charger voltage</td>
<td>(V_{OCHG})</td>
<td>11</td>
<td>Applied for 0 V battery charge function</td>
<td>1.2</td>
<td>–</td>
<td>–</td>
<td>V</td>
</tr>
<tr>
<td>0 V battery charge inhibition battery voltage</td>
<td>(V_{OCHI})</td>
<td>12</td>
<td>Applied for 0 V battery charge inhibition function</td>
<td>–</td>
<td>–</td>
<td>0.5</td>
<td>V</td>
</tr>
</tbody>
</table>

*1. Since products are not screened at low and high temperature, the specification for this temperature range is guaranteed by design, not tested in production.
## Electrical Characteristics (2) Except detection delay time

(Ta = −40 to 85°C unless otherwise specified)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Remark</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Measure-m</th>
<th>ent circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DETENTION VOLTAGE</strong></td>
<td></td>
<td></td>
<td>Overcharge detection voltage</td>
<td>VCUS=3.9 V to 4.4 V</td>
<td>VCU</td>
<td></td>
<td></td>
<td>VCU</td>
<td>-0.055</td>
</tr>
<tr>
<td>Overcharge release voltage</td>
<td>VCL</td>
<td>1</td>
<td>–</td>
<td></td>
<td>VCL</td>
<td></td>
<td></td>
<td>VCL</td>
<td>-0.08</td>
</tr>
<tr>
<td>Overdischarge detection voltage</td>
<td>VDL=2.0 V to 3.0 V</td>
<td>VDL</td>
<td>2</td>
<td>–</td>
<td>VDL</td>
<td></td>
<td></td>
<td>VDL</td>
<td>-0.08</td>
</tr>
<tr>
<td>Overdischarge release voltage</td>
<td>VDU</td>
<td>2</td>
<td>–</td>
<td></td>
<td>VDU</td>
<td></td>
<td></td>
<td>VDU</td>
<td>-0.13</td>
</tr>
<tr>
<td>Overcurrent 1 detection voltage</td>
<td>VIOV1=0.05 V to 0.3 V</td>
<td>VIOV1</td>
<td>3</td>
<td>–</td>
<td>VIOV1</td>
<td></td>
<td></td>
<td>VIOV1</td>
<td>-0.021</td>
</tr>
<tr>
<td>Overcurrent 2 detection voltage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load short-circuiting detection voltage</td>
<td>VSHORT</td>
<td>3</td>
<td>–</td>
<td></td>
<td>VSHORT</td>
<td></td>
<td></td>
<td>VSHORT</td>
<td>-0.13</td>
</tr>
<tr>
<td>Charger detection voltage</td>
<td>VCHA</td>
<td>4</td>
<td>–</td>
<td></td>
<td>VCHA</td>
<td></td>
<td></td>
<td>VCHA</td>
<td>-1.2</td>
</tr>
</tbody>
</table>

**INPUT VOLTAGE, OPERATION VOLTAGE**

| Operation voltage between VDD and VSS | VDSOP1 | – | Internal circuit operating voltage | | | | | | 1.5 | – | 8 | V | – |

| Operation voltage between VDD and VM | VDSOP2 | – | Internal circuit operating voltage | | | | | | 1.5 | – | 28 | V | – |

**CURRENT CONSUMPTION**

| Current consumption in normal operation | IOPE | 5 | VDD=3.5 V, VVM=0 V | | | | | | 0.7 | 3.5 | 8.0 | µA | 2 |

| Current consumption at power down | IPDN | 5 | VDD=1.5 V | | | | | | – | – | 0.1 | µA | 2 |

**OUTPUT RESISTANCE**

| CO pin H resistance | RCOH | 7 | VDD=3.0 V, VCO=3.5 V, VVM=0 V | | | | | | 1.2 | 5 | 15 | kΩ | 4 |

| CO pin L resistance | RCOL | 7 | VDD=0.5 V, VCO=4.5 V, VVM=0 V | | | | | | 1.2 | 5 | 15 | kΩ | 4 |

| DO pin H resistance | RDOH | 8 | VDD=3.0 V, VDO=3.5 V, VVM=0 V | | | | | | 1.2 | 5 | 15 | kΩ | 4 |

| DO pin L resistance | RDOl | 8 | VDO=0.5 V, VDD=VVM=1.8 V | | | | | | 1.2 | 5 | 15 | kΩ | 4 |

**VM INTERNAL RESISTANCE**

| Internal resistance between VM and VDD | RVM | 6 | VDD=1.8 V, VVM=0 V | | | | | | 78 | 300 | 1310 | kΩ | 3 |

| Internal resistance between VM and VSS | RVM | 6 | VDD=3.5 V, VVM=1.0 V | | | | | | 7.2 | 20 | 44 | kΩ | 3 |

**9V BATTERY CHARGING FUNCTION**

| 0 V battery charge starting charger voltage | VSCSH | 11 | Applied for 0 V battery charge function | | | | | | 1.7 | – | – | V | 2 |

| 0 V battery charge inhibition battery voltage | VSCSH | 12 | Applied for 0 V battery charge inhibition function | | | | | | – | – | 0.3 | V | 2 |

*1. Since products are not screened at low and high temperature, the specification for this temperature range is guaranteed by design, not tested in production.
## Electrical Characteristics (3) Detection delay time

### S-8201AAA, AAB, AAC

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Remark</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Measure-m</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>DETAIL TIME (25°C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overcharge detection delay time</td>
<td>t_{CU}</td>
<td>9</td>
<td>−</td>
<td>3.7</td>
<td>4.6</td>
<td>5.5</td>
<td>s</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Overdischarge detection delay time</td>
<td>t_{DL}</td>
<td>9</td>
<td>−</td>
<td>120</td>
<td>150</td>
<td>180</td>
<td>ms</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Overcurrent 1 detection delay time</td>
<td>t_{lOV1}</td>
<td>10</td>
<td>−</td>
<td>7.2</td>
<td>9</td>
<td>11</td>
<td>ms</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Overcurrent 2 detection delay time</td>
<td>t_{lOV2}</td>
<td>10</td>
<td>−</td>
<td>3.6</td>
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### S-8201AAD, AAE, AAF

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<th>Remark</th>
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<td>18</td>
<td>40</td>
<td>ms</td>
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*1. Since products are not screened at low and high temperature, the specification for this temperature range is guaranteed by design.
**Measurement Circuits**

Unless otherwise specified, the output voltage levels “H” and “L” at CO and DO pins are judged by the threshold voltage (1.0 V) of the N channel FET. Judge the CO pin level with respect to $V_{\text{IN}}$ and the DO pin level with respect to $V_{\text{SS}}$.

(1) **Measurement Condition 1, Measurement Circuit 1**

\[
\text{〈〈Overcharge detection voltage, Overcharge release voltage 〉〉}
\]

The overcharge detection voltage ($V_{\text{CU}}$) is defined as the voltage between VDD and VSS at which $V_{\text{CO}}$ goes from "H" to "L" when the voltage $V_{1}$ is gradually increased from the starting condition of $V_{1} = 3.5$ V. The overcharge release voltage ($V_{\text{CL}}$) is defined as the voltage between VDD and VSS at which $V_{\text{CO}}$ goes from "L" to "H" when the voltage $V_{1}$ is then gradually decreased.

The overcharge hysteresis voltage ($V_{\text{HC}}$) is defined as the difference between the overcharge detection voltage ($V_{\text{CU}}$) and the overcharge release voltage ($V_{\text{CL}}$).

(2) **Measurement Condition 2, Measurement Circuit 2**

\[
\text{〈〈Overdischarge detection voltage, Overdischarge release voltage 〉〉}
\]

The overdischarge detection voltage ($V_{\text{DL}}$) is defined as the voltage between VDD and VSS at which $V_{\text{DO}}$ goes from "H" to "L" when the voltage $V_{1}$ is gradually decreased from the starting condition of $V_{1} = 3.5$ V, $V_{2} = 0$ V. The overdischarge release voltage ($V_{\text{DU}}$) is defined as the voltage between VDD and VSS at which $V_{\text{DO}}$ goes from "L" to "H" when the voltage $V_{1}$ is then gradually increased.

The overdischarge hysteresis voltage ($V_{\text{HD}}$) is defined as the difference between the overcharge release voltage ($V_{\text{DU}}$) and the overdischarge detection voltage ($V_{\text{DL}}$).

(3) **Measurement Condition 3, Measurement Circuit 2**

\[
\text{〈〈Overcurrent 1 detection voltage, Overcurrent 2 detection voltage, Load short-circuiting detection voltage 〉〉}
\]

The overcurrent 1 detection voltage is defined by the voltage between VM and VSS whose delay time for changing $V_{\text{DO}}$ from "H" to "L" lies between the minimum and the maximum value of the overcurrent 1 detection delay time when the voltage $V_{2}$ is increased rapidly within 10 $\mu$s from the starting condition $V_{1}=3.5$ V and $V_{2}=0$ V.

The overcurrent 2 detection voltage is defined by the voltage between VM and VSS whose delay time for changing $V_{\text{DO}}$ from "H" to "L" lies between the minimum and the maximum value of the overcurrent 2 detection delay time when the voltage $V_{2}$ is increased rapidly within 10 $\mu$s from the starting condition $V_{1}=3.5$ V and $V_{2}=0$ V.

The load short-circuiting detection voltage is defined by the voltage between VM and VSS whose delay time for changing $V_{\text{DO}}$ from "H" to "L" lies between the minimum and the maximum value of the load short-circuiting detection delay time when the voltage $V_{2}$ is increased rapidly within 10 $\mu$s from the starting condition $V_{1}=3.5$ V and $V_{2}=0$ V.

(4) **Measurement Condition 4, Measurement Circuit 2**

\[
\text{〈〈Charger detection voltage, abnormal charge current detection voltage 〉〉}
\]

Set $V_{1}=1.8$ V and $V_{2}=0$ V. Increase $V_{1}$ gradually until $V_{1}=V_{\text{DL}}+(V_{\text{HD}}/2)$, then decrease $V_{2}$ from 0 V gradually. The voltage between VM and VSS when $V_{\text{DO}}$ goes from "L" to "H" is the charger detection voltage ($V_{\text{CHA}}$). Charger detection voltage can be measured only in the product whose overdischarge hysteresis $V_{\text{HD}} \neq 0$.

Set $V_{1}=3.5$ V and $V_{2}=0$ V. Decrease $V_{2}$ from 0 V gradually. The voltage between VM and VSS when $V_{\text{DO}}$ goes from "H" to "L" is the abnormal charge current detection voltage. The abnormal charge current detection voltage has the same value as the charger detection voltage ($V_{\text{CHA}}$).
(5) Measurement Condition 5, Measurement Circuit 2
 〈〈 Normal operation current consumption, Power-down current consumption 〉〉
  Set V1=3.5 V and V2=0 V under normal condition. The current $I_{OPN}$ flowing through VDD pin is the
  normal operation consumption current ($I_{OPN}$).
  Set V1=V2=1.5 V under overdischarge condition. The current $I_{DD}$ flowing through VDD pin is the
  power-down current consumption ($I_{PDN}$).

(6) Measurement Condition 6, Measurement Circuit 3
  〈〈 Internal resistance between VM and VDD, Internal resistance between VM and VSS 〉〉
  Set V1=1.8 V and V2=0 V. The resistance between VM and VDD is the internal resistance ($R_{VMN}$)
  between VM and VDD.
  Set V1=3.5 V and V2=1.0 V. The resistance between VM and VSS is the internal resistance ($R_{VMS}$)
  between VM and VSS.

(7) Measurement Condition 7, Measurement Circuit 4
  〈〈 CO pin H resistance, CO pin L resistance 〉〉
  Set V1=3.5 V, V2=0 V and V3=3.0 V. CO pin resistance is the CO pin H resistance ($R_{COPH}$).
  Set V1=4.5 V, V2=0 V and V3=0.5 V. CO pin resistance is the CO pin L resistance ($R_{COPH}$).

(8) Measurement Condition 8, Measurement Circuit 4
  〈〈 DO pin H resistance, DO pin L resistance 〉〉
  Set V1=3.5 V, V2=0 V and V4=3.0 V. DO pin resistance is the DO pin H resistance ($R_{DOH}$).
  Set V1=1.8 V, V2=0 V and V4=0.5 V. DO pin resistance is the DO pin L resistance ($R_{DOH}$).

(9) Measurement Condition 9, Measurement Circuit 5
  〈〈 Overcharge detection delay time, Overdischarge detection delay time 〉〉
  The overcharge detection delay time ($t_{CU}$) is the time needed for $V_{CO}$ to change from "H" to "L" just
  after the V1 rapid increase within 10 $\mu$s from the overcharge detection voltage ($V_{CU}$) + 0.2 V to the
  overcharge detection voltage ($V_{CU}$) - 0.2 V in the condition V2=0 V.
  The overdischarge detection delay time ($t_{DL}$) is the time needed for $V_{DO}$ to change from "H" to "L" just
  after the V1 rapid decrease within 10 $\mu$s from the overdischarge detection voltage ($V_{DL}$)+0.2 V to the
  overdischarge detection voltage ($V_{DL}$) - 0.2 V in the condition V2=0 V.

(10) Measurement Condition 10, Measurement Circuit 5
  〈〈 Overcurrent 1 detection delay time, Overcurrent 2 detection delay time, Load short-circuiting
  detection delay time, Abnormal charge current detection delay time 〉〉
  Set V1=3.5 V and V2=0 V. Increase V2 from 0 V to 0.35 V momentarily (within 10 $\mu$s). The time
  needed for $V_{DO}$ to go "L" is overcurrent 1 detection delay time ($t_{IOV1}$).
  Set V1=3.5 V and V2=0 V. Increase V2 from 0 V to 0.7 V momentarily (within 10 $\mu$s). The time needed
  for $V_{DO}$ to go "L" is overcurrent 2 detection delay time ($t_{IOV2}$).
  Set V1=3.5 V and V2=0 V. Increase V2 from 0 V to 1.6 V momentarily (within 10 $\mu$s). The time needed
  for $V_{DO}$ to go "L" is the load short-circuiting detection delay time ($t_{SHORT}$).
  Set V1=3.5 V and V2=0 V. Decrease V2 from 0 V to -1.1 V momentarily (within 10 $\mu$s). The time
  needed for $V_{CO}$ to go "L" is the abnormal charge current detection delay time. The abnormal charge
current detection delay time has the same value as the overcharge detection delay time.
(11) Measurement Condition 11, Measurement Circuit 2 (Product with 0 V battery charge function)

Set V1=V2=0 V and decrease V2 gradually. The voltage between VDD and VM when VCO goes “H” (VVM + 0.1 V or higher) is the 0 V battery charge starting charger voltage (VCHA).

(12) Measurement Condition 12, Measurement Circuit 2 (Product with 0 V battery charge inhibition function)

Set V1=0 V and V2=-4 V and increase V1 gradually. The voltage between VDD and VSS when VCO goes “H” (VVM + 0.1 V or higher) is the 0 V battery charge inhibition battery voltage (VINH).

(13) Measurement Condition 13, Measurement Circuit 5

Set V2 = 0 V. Increase V1 from overcharge detection voltage (VCU) – 0.2 V to overcharge detection voltage (VCU) + 0.2 V momentarily (within 10 μs), then decrease V1 again to overcharge detection voltage (VCU) – 0.2 V momentarily (within 10 μs) after half the overcharge detection delay time (tCU) has elapsed. Following ttr Min., again increase V1 to overcharge detection voltage (VCU) + 0.2 V momentarily (within 10 μs) and check that VCO changes from “H” to “L” after the overcharge detection delay time from when V1 is first increased momentarily (within 10 μs) to overcharge detection voltage (VCU) + 0.2 V.

Set V2 = 0V. Increase V1 from overcharge detection voltage (VCU) – 0.2 V to overcharge detection voltage (VCU) + 0.2 V momentarily (within 10 μs), then decrease V1 again to overcharge detection voltage (VCU) – 0.2 V momentarily (within 10 μs) after half the overcharge detection delay time (tCU) has elapsed. Following ttr Max., again increase V1 to overcharge detection voltage (VCU) + 0.2 V momentarily (within 10 μs) and check that VCO stays “H” after the overcharge detection delay time from when V1 is first increased momentarily (within 10 μs) to overcharge detection voltage (VCU) + 0.2 V.
Figure 4
Description of Operation

Normal condition

The S-8201 monitors the voltage of the battery connected between VDD and VSS pin and the voltage difference between VM and VSS pin to control charging and discharging. When the battery voltage is in the range from the overdischarge detection voltage \( V_{DL} \) to the overcharge detection voltage \( V_{CU} \), and the VM pin voltage is in the range from the charger detection voltage \( V_{CHA} \) to the overcurrent 1 detection voltage \( V_{IOV1} \), the IC turns both the charging and discharging control FETs on. This condition is called the normal condition, and in this condition charging and discharging can be carried out freely.

Note: When a battery is connected to the IC for the first time, the battery may not enter dischargeable state. In this case, set the VM pin voltage equal to the VSS voltage or connect a charger to enter the normal condition.

Overcurrent condition (Detection of Overcurrent 1, Overcurrent 2, and Load short-circuiting)

When the condition in which VM pin voltage is equal to or higher than the overcurrent detection voltage, which caused by the excess of discharging current over a specified value, continues longer than the overcharge detection delay time in a battery under the normal condition, the S-8201 turns the discharging control FET off to stop discharging. This condition is called the overcurrent condition.

Though the VM and VSS pins are shorted by the resistor in the IC \( R_{VMS} \) under the overcurrent condition provided that the VM pin voltage is pulled to the VDD level by the load as long as the load is connected.

The VM pin voltage returns to VSS level when the load is released. The overcurrent condition returns to the normal condition when the impedance between the EB+ and EB- pin (see Figure 10) becomes higher than the automatic recoverable load resistance and the IC detects that the VM pin potential is lower than the overcurrent 1 detection voltage \( V_{IOV1} \).

Note: The automatic recoverable load resistance changes depending on the battery voltage and overcurrent 1 detection voltage settings.

Overcharge condition

When the battery voltage becomes higher than the overcharge detection voltage \( V_{CU} \) during charging under the normal condition and the detection continues for the overcharge detection delay time \( t_{CU} \) or longer, the S-8201 turns the charging control FET off to stop charging. This condition is called the overcharge condition.

The overcharge condition is released by the following two cases: (1) and (2):

1. When the battery voltage falls below the overcharge release voltage, which is equal to the overcharge detection voltage \( V_{CU} \)− overcharge detection hysteresis voltage \( V_{HC} \), the S-8201 turns the charging control FET on and returns to the normal condition.

2. When a load is connected and discharging starts, the S-8201 turns the charging control FET on and returns to the normal condition. Just after the load is connected and discharging starts, the discharging current flows through the parasitic diode in the charging control FET. At this moment the VM pin potential becomes \( V_f \) volt, the voltage for the parasitic diode, higher than VSS level. When the battery voltage goes under the overcharge detection voltage \( V_{CU} \) and provided that the VM pin voltage is higher than the overcurrent 1 detection voltage, the S-8201 releases the overcharge condition.

Note:
- If the battery is charged to a voltage higher than the overcharge detection voltage \( V_{CU} \) and the battery voltage does not fall below the overcharge detection voltage \( V_{CU} \) even when a heavy load is connected, the detection of overcurrent 1, overcurrent 2 and load short-circuiting does not work. Since an actual battery has the internal impedance of several dozens of mΩ, the battery voltage drops immediately after a heavy load which causes overcurrent is connected, and the detection of overcurrent 1, overcurrent 2 and load short-circuiting then works.

- When a charger is connected after the overcharge detection, the overcharge condition is not released even if the battery voltage is below the overcharge release voltage \( V_{CL} (=V_{CU}−V_{HC}) \). The overcharge condition is released when the VM pin voltage goes over the charger detection voltage \( V_{CHA} \) by removing the charger.

- If the overcharge release pulse for less than the overcharge timer reset delay time \( t_{tr} \) is input during the overcharge detection delay time \( t_{CU} \) that after exceeding the overcharge detection voltage \( V_{CU} \), the \( t_{CU} \) keeps the count. However, if the overcharge release pulse is input for \( t_{tr} \) or longer under the same conditions, the \( t_{CU} \) count is reset.
**Overdischarge condition**

When the battery voltage falls below the overdischarge detection voltage \((V_{DL})\) during discharging under the normal condition and the detection continues for the overdischarge detection delay time \((t_{DL})\) or longer, the S-8201 turns the discharging control FET off to stop discharging. This condition is called the overdischarge condition. When the discharging control FET turns off, the VM pin voltage is pulled up by the resistor between VM and VDD in the IC \((R_{VM})\). The voltage difference between VM and VDD then falls below 1.3 V (typ.), the current consumption is reduced to the power-down current consumption \((I_{PDN})\). This condition is called the power-down condition.

The power-down condition is released when a charger is connected and the voltage difference between VM and VDD becomes 1.3 V (typ.) or higher. Moreover when the battery voltage becomes the overdischarge detection voltage \((V_{DL})\) or higher the S-8201 turns the discharging FET on and returns to the normal condition.

**Charger detection**

When a battery in the overdischarge condition is connected to a charger and provided that the VM pin voltage is lower than the charger detection voltage \((V_{CHA})\), the S-8201 releases the overdischarge condition and turns the discharging control FET on as the battery voltage becomes equal to or higher than the overdischarge detection voltage \((V_{DL})\) since the charger detection function works. This action is called charger detection.

When a battery in the overdischarge condition is connected to a charger and provided that the VM pin voltage is not lower than the charger detection voltage \((V_{CHA})\), the S-8201 releases the overdischarge condition when the battery voltage reaches the overdischarge detection voltage \((V_{DL}) + \text{overdischarge hysteresis} (V_{HD})\) or higher.

**Abnormal charge current detection**

If the VM pin voltage falls below the charger detection voltage \((V_{CHA})\) during charging under normal condition and it continues for the overcharge detection delay time \((t_{CU})\) or longer, the charging control FET turns off and charging stops. This action is called the abnormal charge current detection. Abnormal charge current detection works when the DO pin voltage is “H” and the VM pin voltage falls below the charger detection voltage \((V_{CHA})\). Consequently, if an abnormal charge current flows to an over-discharged battery, the S-8201 turns the charging control FET off and stops charging after the battery voltage becomes higher than the overdischarge detection voltage which make the DO pin voltage “H”, and still after the overcharge detection delay time \((t_{CU})\) elapses.

Abnormal charge current detection is released when the voltage difference between VM pin and VSS pin becomes less than charger detection voltage \((V_{CHA})\).

**Delay circuits**

The detection delay times are generated by dividing the approximate 3.5 kHz clock with a counter.

**Note**

- The detection delay time for overcurrent 2 and load and short-circuiting start when the overcurrent 1 is detected. As soon as the overcurrent 2 or load short-circuiting is detected over the detection delay time for overcurrent 2 or load short-circuiting after the detection of overcurrent 1, the S-8201 turns the discharging control FET off.
When the overcurrent is detected and it continues for longer than the overdischarge detection delay time without releasing the load, the condition changes to the power-down condition when the battery voltage falls below the overdischarge detection voltage.

When the battery voltage falls below the overdischarge detection voltage due to the overcurrent, the S-8201 turns the discharging control FET off by the overcurrent detection. And in this case the recovery of the battery voltage is so slow that the battery voltage after the overdischarge detection delay time is still lower than the overdischarge detection voltage, the S-8201 transits to the power-down condition.

DP pin
The DP pin is a test pin for delay time acceleration. When the DP pin is set to the VDD potential, the delay time is reduced by about 1/15 to 1/40. (25°C) The DP pin should be left open during normal operation.

0V battery charge function (*1) (*2)
This function is used to recharge the connected battery whose voltage is 0 V due to the self-discharge. When the 0V battery charge starting charger voltage (V_{CHA}) or higher is applied between EB+ and EB- pins by connecting a charger, the charging control FET gate is fixed to VDD pin voltage. When the voltage between the gate and source of the charging control FET becomes equal to or higher than the turn-on voltage by the charger voltage, the charging control FET turns on to start charging. At this time, the discharging control FET is off and the charging current flows through the internal parasitic diode in the discharging control FET. When the battery voltage becomes equal to or higher than the overdischarge release voltage (V_{DU}), the S-8201 enters the normal condition.

0V battery charge inhibition function (*1)
This function inhibits the recharging when a battery which is short-circuited (0 V) internally is connected. When the battery voltage is 0.6 V (typ.) or lower, the charging control FET gate is fixed to EB- pin voltage to inhibit charging. When the battery voltage is the 0V battery charge inhibition battery voltage (V_{BINH}) or higher, charging can be performed.

(*1) Some battery providers do not recommend charging for completely self-discharged battery. Please ask battery providers before determining the 0V battery charge function.

(*2) The 0V battery charge function has higher priority than the abnormal charge current detection function. Consequently, a product with the 0V battery charge function charges a battery forcibly and abnormal charge current cannot be detected when the battery voltage is low.
■ Operation Timing Chart

1. Overcharge and overdischarge detection

![Diagram of overcharge and overdischarge detection](image)

- Battery voltage
- DO pin
- CO pin
- VM pin
- Charger connection
- Load connection

Note: (1) Normal condition, (2) Overcharge condition, (3) Overdischarge condition, (4) Overcurrent condition

The charger is supposed to charge with constant current.

Figure 6

2. Overcurrent detection

![Diagram of overcurrent detection](image)

- Battery voltage
- DO pin
- CO pin
- VM pin
- Charger connection
- Load connection

Note: (1) Normal condition, (2) Overcharge condition, (3) Overdischarge condition, (4) Overcurrent condition

The charger is supposed to charge with constant current.

Figure 7
3. Charger detection

Battery voltage

DO pin

CO pin

VM pin

Note: (1) Normal condition, (2) Overcharge condition, (3) Overdischarge condition, (4) Overcurrent condition

The charger is supposed to charge with constant current.

Figure 8

4. Abnormal charge current detection

Battery voltage

DO pin

CO pin

VM pin

Note: (1) Normal condition, (2) Overcharge condition, (3) Overdischarge condition, (4) Overcurrent condition

The charger is supposed to charge with constant current.

Figure 9
An Example for Battery Protection IC Connection

![Diagram of battery protection IC connection](image)

**Figure 10**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parts</th>
<th>Purpose</th>
<th>Recommend</th>
<th>min.</th>
<th>max.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>FET1</td>
<td>N channel MOSFET</td>
<td>Charge control</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>Threshold voltage ≤ overdischarge detection voltage 1) Gate to source withstand voltage ≥ Charger voltage</td>
</tr>
<tr>
<td>FET2</td>
<td>N channel MOSFET</td>
<td>Discharge control</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>Threshold voltage ≤ overdischarge detection voltage 1) Gate to source withstand voltage ≥ Charger voltage</td>
</tr>
<tr>
<td>R1</td>
<td>Resistor</td>
<td>ESD protection For power fluctuation</td>
<td>470 Ω</td>
<td>300 Ω</td>
<td>1 kΩ</td>
<td>Resistance should be as small as possible to avoid lowering of the overcharge detection accuracy caused by VDD pin current. 2)</td>
</tr>
<tr>
<td>C1</td>
<td>Capacitor</td>
<td>For power fluctuation</td>
<td>0.1 µF</td>
<td>0.022 µF</td>
<td>1.0 µF</td>
<td>Install a capacitor of 0.022 µF or higher between VDD and VSS. 3)</td>
</tr>
<tr>
<td>R2</td>
<td>Resistor</td>
<td>Protection for reverse connection of a charger</td>
<td>2 kΩ</td>
<td>300 Ω</td>
<td>4 kΩ</td>
<td>Select a resistance as large as possible to prevent current when a charger is reversely connected. 4)</td>
</tr>
</tbody>
</table>

1) If the threshold voltage of an EFT is low, the FET may not cut the charging current. If an FET with a threshold voltage equal to or higher than the overdischarge detection voltage is used, discharging may be stopped before overdischarge is detected.

2) If R1 has a high resistance, the voltage between VDD and VSS may exceed the absolute maximum rating when a charger is connected reversely since the current flows from the charger to the IC. Insert a resistor of 300 Ω or higher as R1 for ESD protection.

3) If a capacitor of less than 0.022 µF is installed as C1, DO may oscillate when load short-circuiting is detected. Be sure to install a capacitor of 0.022 µF or higher as C1.

4) If R2 has a resistance higher than 4kΩ, the charging current may not be cut when a high-voltage charger is connected.

**Note:**

- The DP pin should be open.
- The above connection diagram and constants do not guarantee proper operation. Evaluate upon actual application and determine constants properly.
Precautions

- Pay attention to the operating conditions for input/output voltage and load current so that the loss in the IC does not exceed the permissible loss (power dissipation) of the package.

- Do not apply an electrostatic discharge to this IC that exceeds the performance ratings of the built-in electrostatic protection circuit.

- Seiko Instruments Inc. shall not be responsible for any patent infringement by products including the S-8201 series in connection with the method of using the S-8201 series in such products, the product specifications or the country of destination thereof.
- **Characteristics (typical characteristics)**

  1. Detection/release voltage temperature characteristics

  **Overcharge detection voltage vs. temperature**

  ![Graph](image1.png)

  **Overcharge release voltage vs. temperature**

  ![Graph](image2.png)

  **Overdischarge detection voltage vs. temperature**

  ![Graph](image3.png)

  **Overdischarge release voltage vs. temperature**

  ![Graph](image4.png)

  **Overcurrent 1 detection voltage vs. temperature**

  ![Graph](image5.png)

  **Overcurrent 2 detection voltage vs. temperature**

  ![Graph](image6.png)

  **Load short-circuiting detection voltage vs. temperature**

  ![Graph](image7.png)
2. Current consumption temperature characteristics

Current consumption vs. temperature in normal mode

Current consumption vs. temperature in power-down mode

3. Current consumption power voltage characteristics (Ta=25°C)

Current consumption power supply voltage dependency

4. Detection/release delay time temperature characteristics

Overcharge detection delay time vs. temperature

Overcharge release delay time vs. temperature

Overdischarge detection delay time vs. temperature
5. Delay time power-voltage characteristics (Ta=25°C)

- Overcurrent 1 detection delay time vs. power supply voltage dependency
- Overcurrent 2 detection delay time vs. power supply voltage dependency
- Load short-circuiting delay time vs. power supply voltage dependency
6. CO pin/DO pin output current characteristics (Ta=25°C)

**CO pin source current characteristics**

$V_{DD}=3.5V, V_M=V_{SS}=0V$

**DO pin source current characteristics**

$V_{DD}=3.5V, V_M=V_{SS}=0V$

**CO pin sink current characteristics**

$V_{DD}=4.5V, V_M=V_{SS}=0V$

**DO pin sink current characteristics**

$V_{DD}=1.8V, V_M=V_{SS}=0V$
### SOT-23-6

#### Dimensions

- Unit: mm
- **No. MP006-A-P-SD-1.1**

#### Taping Specifications

- 4.0 ± 0.1 (10 pitches: 40.0 ± 0.2)
- Ø 1.5 ± 0.1
- 0.25 ± 0.1

#### Reel Specifications

- 3000 pcs/reel
- Enlarged drawing in the central part

- **No. MP006-A-C-SD-3.1**
- **No. MP006-A-R-SD-2.1**
6-Pin SNB(B) [SNB6B(1820)]

**Dimensions**

Unit:mm

- **No.: BD006-A-P-SD-1.0**

**Taping Specifications**

- **No.: BD006-A-C-SD-2.0**

**Reel Specifications**

- **No.: BD006-A-R-SD-1.0**
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