The S-8245A/C Series is a protection IC for 3-serial to 5-serial cell lithium-ion rechargeable batteries, which includes high-accuracy voltage detection circuits and delay circuits. It is suitable for protecting 3-serial to 5-serial cell lithium-ion rechargeable battery packs from overcharge, overdischarge, and overcurrent. Cascade connection using the S-8245A/C Series realizes protecting 6-serial or more cells lithium-ion rechargeable battery packs.

Connecting an NTC, it allows for the temperature detection at four different points: high temperature detection during charging, low temperature detection during charging, high temperature detection during discharging, and low temperature detection during discharging.

### Features

- **High-accuracy voltage detection for each cell**
  
  - Overcharge detection voltage \( n (n = 1 \text{ to } 5) \): \( 3.550 \text{ V to } 4.600 \text{ V} \) (50 mV step) 
  
  - Overcharge release voltage \( n (n = 1 \text{ to } 5) \): \( 3.150 \text{ V to } 4.600 \text{ V} \) 
  
  - Overdischarge detection voltage \( n (n = 1 \text{ to } 5) \): \( 2.000 \text{ V to } 3.200 \text{ V} \) (100 mV step) 
  
  - Overdischarge release voltage \( n (n = 1 \text{ to } 5) \): \( 2.000 \text{ V to } 3.400 \text{ V} \) 

- **Three-level discharge overcurrent detection**
  
  - Discharge overcurrent 1 detection voltage: \( 0.020 \text{ V to } 0.300 \text{ V} \) (10 mV step) 
  
  - Discharge overcurrent 2 detection voltage: \( 0.040 \text{ V to } 0.500 \text{ V} \) (20 mV step) 
  
  - Load short-circuiting detection voltage: \( 0.100 \text{ V to } 1.000 \text{ V} \) (25 mV step) 

- **Charge overcurrent detection**
  
  - Charge overcurrent detection voltage: \( -0.300 \text{ V to } -0.020 \text{ V} \) (10 mV step) 

- **Each delay time is settable by an external capacitor**
  
  (Load short-circuiting detection delay time and temperature detection delay time are internally fixed)

- **Independent control of charge inhibition, discharge inhibition, and power-saving by each control pin**

- **0 V battery charge function is selectable**
  
  Available, unavailable

- **Power-down function is selectable**
  
  Available, unavailable

- **CeT pin internal resistance value is selectable**
  
  \( 831 \text{ kΩ typ.}, 8.31 \text{ MΩ typ.} \)

- **CO and DO pin output voltage is limited to 15 V max. respectively**

- **Switching control for 3-serial to 5-serial cell is possible by inputting voltage to the SEL1 pin and the SEL2 pin**

- **Protection of 6-serial or more cells is possible by cascade connection**

- **Temperature detection is possible at four different points by connecting an NTC**
  
  - High temperature detection ratio during charging / discharging: \( 0.600 \text{ to } 0.900 (0.005 \text{ step}) \) 
  
  - Low temperature detection ratio during charging / discharging: \( 0.030 \text{ to } 0.400 (0.005 \text{ step}) \) 

- **High-withstand voltage**
  
  Absolute maximum rating 28 V

- **Wide operation voltage range**
  
  5 V to 24 V

- **Wide operation temperature range**
  
  \( \text{Ta = -40°C to +85°C} \)

- **Low current consumption**
  
  - During operation: \( 20 \text{ μA max. (Ta = +25°C)} \)
  
  - During power-down: \( 0.5 \text{ μA max. (Ta = +25°C)} \)
  
  - During power-saving: \( 0.1 \text{ μA max. (Ta = +25°C)} \)

- **Lead-free (Sn 100%), halogen-free**

*1. Overcharge release voltage = Overcharge detection voltage − Overcharge hysteresis voltage

  (Overcharge hysteresis voltage \( n (n = 1 \text{ to } 5) \) is selectable in 0 V to 0.4 V in 50 mV step)

*2. Overdischarge release voltage = Overdischarge detection voltage + Overdischarge hysteresis voltage

  (Overdischarge hysteresis voltage \( n (n = 1 \text{ to } 5) \) is selectable in 0 V to 0.7 V in 100 mV step)

### Application

- Lithium-ion rechargeable battery pack

### Package

- 24-Pin SSOP

ABLIC Inc.
 Remark  Diodes in the figure are parasitic diodes.
Product Name Structure

1. **Product name**

   S-8245 x x - FGT1 U

   - Environmental code
     - U: Lead-free (Sn 100%), halogen-free
   - Package abbreviation and IC packing specifications
     - FGT1: 24-Pin SSOP, Tape
   - Serial code
     - Sequentially set from AA to ZZ
   - Product type
     - A: For application circuit with an integrated charge and discharge path
     - C: For application circuit with separate charge and discharge paths

*1. Refer to the tape drawing.
*2. Refer to "3. Product name list".

2. **Package**

   **Table 1  Package Drawing Code**

<table>
<thead>
<tr>
<th>Package Name</th>
<th>Dimension</th>
<th>Tape</th>
<th>Reel</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-Pin SSOP</td>
<td>FS024-B-P-SD</td>
<td>FS024-B-C-SD</td>
<td>FS024-B-R-SD</td>
</tr>
</tbody>
</table>

ABLIC Inc.
### 3. Product name list

#### 3.1 S-8245A Series

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>S-8245AAA-FGT1U</td>
<td>4.100 V</td>
<td>4.050 V</td>
<td>2.600 V</td>
<td>2.700 V</td>
<td>0.020 V</td>
<td>0.040 V</td>
<td>0.100 V</td>
<td>−0.020 V</td>
</tr>
<tr>
<td>S-8245AAB-FGT1U</td>
<td>4.350 V</td>
<td>4.150 V</td>
<td>2.400 V</td>
<td>2.700 V</td>
<td>0.150 V</td>
<td>0.300 V</td>
<td>0.500 V</td>
<td>−0.150 V</td>
</tr>
<tr>
<td>S-8245AAC-FGT1U</td>
<td>4.250 V</td>
<td>4.150 V</td>
<td>2.500 V</td>
<td>3.000 V</td>
<td>0.100 V</td>
<td>0.200 V</td>
<td>0.500 V</td>
<td>−0.100 V</td>
</tr>
</tbody>
</table>

#### Table 2 (2 / 2)

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>S-8245AAA-FGT1U</td>
<td>Available</td>
<td>831 kΩ</td>
<td>0.670</td>
<td>0.270</td>
<td>0.795</td>
<td>0.190</td>
</tr>
<tr>
<td>S-8245AAB-FGT1U</td>
<td>Available</td>
<td>831 kΩ</td>
<td>0.850</td>
<td>0.150</td>
<td>0.900</td>
<td>0.100</td>
</tr>
<tr>
<td>S-8245AAC-FGT1U</td>
<td>Available</td>
<td>831 kΩ</td>
<td>0.670</td>
<td>0.270</td>
<td>0.795</td>
<td>0.190</td>
</tr>
</tbody>
</table>

*1. 0 V battery charge function "available" / "unavailable" is selectable.
*2. Power-down function "available" / "unavailable" is selectable.
*3. CIT pin internal resistance value 831 kΩ typ. / 8.31 MΩ typ. is selectable.

**Remark** Please contact our sales office for products other than those specified above.

#### 3.2 S-8245C Series

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>S-8245CAA-FGT1U</td>
<td>4.100 V</td>
<td>4.050 V</td>
<td>2.600 V</td>
<td>2.700 V</td>
<td>0.020 V</td>
<td>0.040 V</td>
<td>0.100 V</td>
<td>−0.020 V</td>
</tr>
<tr>
<td>S-8245CAB-FGT1U</td>
<td>4.250 V</td>
<td>4.150 V</td>
<td>2.500 V</td>
<td>3.000 V</td>
<td>0.100 V</td>
<td>0.200 V</td>
<td>0.500 V</td>
<td>−0.100 V</td>
</tr>
</tbody>
</table>

#### Table 3 (2 / 2)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>S-8245CAA-FGT1U</td>
<td>Unavailable</td>
<td>831 kΩ</td>
<td>0.670</td>
<td>0.270</td>
<td>0.795</td>
<td>0.190</td>
</tr>
<tr>
<td>S-8245CAB-FGT1U</td>
<td>Unavailable</td>
<td>831 kΩ</td>
<td>0.670</td>
<td>0.270</td>
<td>0.795</td>
<td>0.190</td>
</tr>
</tbody>
</table>

*1. 0 V battery charge function "available" / "unavailable" is selectable.
*2. Power-down function "available" / "unavailable" is selectable.
*3. CIT pin internal resistance value 831 kΩ typ. / 8.31 MΩ typ. is selectable.

**Remark** Please contact our sales office for products other than those specified above.
BATTERY PROTECTION IC FOR 3-SERIAL TO 5-SERIAL CELL PACK

Rev.1.4_00

S-8245A/C Series

1. Pin Configuration

   24-Pin SSOP

   Top view

   Figure 2

   Table 4

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TH</td>
<td>Input pin for temperature detection</td>
</tr>
<tr>
<td>2</td>
<td>VDD</td>
<td>Input pin for positive power supply, connection pin for positive voltage of battery 1</td>
</tr>
<tr>
<td>3</td>
<td>VC1</td>
<td>Connection pin for positive voltage of battery 1</td>
</tr>
<tr>
<td>4</td>
<td>VC2</td>
<td>Connection pin for negative voltage of battery 1, connection pin for positive voltage of battery 2</td>
</tr>
<tr>
<td>5</td>
<td>VC3</td>
<td>Connection pin for negative voltage of battery 2, connection pin for positive voltage of battery 3</td>
</tr>
<tr>
<td>6</td>
<td>VC4</td>
<td>Connection pin for negative voltage of battery 3, connection pin for positive voltage of battery 4</td>
</tr>
<tr>
<td>7</td>
<td>VC5</td>
<td>Connection pin for negative voltage of battery 4, connection pin for positive voltage of battery 5</td>
</tr>
<tr>
<td>8</td>
<td>VSS</td>
<td>Input pin for negative power supply, connection pin for negative voltage of battery 5</td>
</tr>
<tr>
<td>9</td>
<td>VINI</td>
<td>Voltage detection pin between VSS pin and VINI pin</td>
</tr>
<tr>
<td>10</td>
<td>SEL1</td>
<td>Switching pins for number of cells in series</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[SEL1, SEL2] = [&quot;L&quot;, &quot;L&quot;] : 5-serial cell</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[SEL1, SEL2] = [&quot;L&quot;, &quot;H&quot;] : 4-serial cell</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[SEL1, SEL2] = [&quot;H&quot;, &quot;L&quot;] : 3-serial cell</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[SEL1, SEL2] = [&quot;H&quot;, &quot;H&quot;] : Setting inhibited</td>
</tr>
<tr>
<td>11</td>
<td>SEL2</td>
<td>Capacitor connection pin for delay for charge overcurrent detection</td>
</tr>
<tr>
<td>12</td>
<td>CICT</td>
<td>Capacitor connection pin for delay for overcharge detection voltage</td>
</tr>
<tr>
<td>13</td>
<td>CCT</td>
<td>Capacitor connection pin for delay for overdischarge detection voltage</td>
</tr>
<tr>
<td>14</td>
<td>CDT</td>
<td>Capacitor connection pin for delay for overdischarge detection voltage</td>
</tr>
<tr>
<td>15</td>
<td>CIT</td>
<td>Capacitor connection pin for delay for discharge overcurrent 1 detection</td>
</tr>
<tr>
<td>16</td>
<td>CIT2</td>
<td>Capacitor connection pin for delay for discharge overcurrent 2 detection</td>
</tr>
<tr>
<td>17</td>
<td>PSO</td>
<td>Output pin for power-saving signal (CMOS output)</td>
</tr>
<tr>
<td>18</td>
<td>DO</td>
<td>Connection pin of discharge control FET gate (CMOS output)</td>
</tr>
<tr>
<td>19</td>
<td>CO</td>
<td>Connection pin of charge control FET gate (Pch open-drain output)</td>
</tr>
<tr>
<td>20</td>
<td>VM</td>
<td>Voltage detection pin between VSS pin and VM pin</td>
</tr>
<tr>
<td>21</td>
<td>CTLC</td>
<td>Control pin for CO pin output</td>
</tr>
<tr>
<td>22</td>
<td>CTLD</td>
<td>Control pin for DO pin output</td>
</tr>
<tr>
<td>23</td>
<td>PSI</td>
<td>Control pin for Power-saving</td>
</tr>
<tr>
<td>24</td>
<td>VREG</td>
<td>Voltage output pin for temperature detection</td>
</tr>
</tbody>
</table>

ABLIC Inc.
- **Absolute Maximum Ratings**

  **Table 5**  
  (Ta = +25°C unless otherwise specified)

<table>
<thead>
<tr>
<th>Item</th>
<th>Symbol</th>
<th>Applied Pin</th>
<th>Absolute Maximum Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input voltage between VDD pin and VSS pin</td>
<td>$V_{DS}$</td>
<td>VDD, VC1, VC2, VC3, VC4, VC5, CCT, CDT, CIT, CIT2, CICT, SEL1, SEL2, TH</td>
<td>$V_{SS} - 0.3$ to $V_{SS} + 28$</td>
<td>V</td>
</tr>
<tr>
<td>Input pin voltage 1</td>
<td>$V_{IN1}$</td>
<td>VM, VINI, PSI</td>
<td>$V_{DD} - 0.3$ to $V_{DD} + 0.3$</td>
<td>V</td>
</tr>
<tr>
<td>Input pin voltage 2</td>
<td>$V_{IN2}$</td>
<td>VDD - 28</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Input pin voltage 3</td>
<td>$V_{IN3}$</td>
<td>VM, VINI</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Output pin voltage 1</td>
<td>$V_{OUT1}$</td>
<td>DO, PSO, VREG</td>
<td>$V_{SS} - 0.3$ to $V_{SS} + 28$</td>
<td>V</td>
</tr>
<tr>
<td>Output pin voltage 2</td>
<td>$V_{OUT2}$</td>
<td>VDD - 28</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Operation ambient temperature</td>
<td>$T_{opr}$</td>
<td>-</td>
<td>-40 to +85</td>
<td>°C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>$T_{stg}$</td>
<td>-</td>
<td>-40 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.

- **Thermal Resistance Value**

  **Table 6**

<table>
<thead>
<tr>
<th>Item</th>
<th>Symbol</th>
<th>Condition</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junction-to-ambient thermal resistance$^{*1}$</td>
<td>$\theta_{JA}$</td>
<td>24-Pin SSOP</td>
<td>Board A</td>
<td>70</td>
<td>-</td>
<td>°C/W</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Board B</td>
<td>60</td>
<td>-</td>
<td>°C/W</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Board C</td>
<td>-</td>
<td>-</td>
<td>°C/W</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Board D</td>
<td>-</td>
<td>-</td>
<td>°C/W</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Board E</td>
<td>-</td>
<td>-</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

  *1. Test environment: compliance with JEDEC STANDARD JESD51-2A

  **Remark** Refer to "**Power Dissipation**" and "**Test Board**" for details.
### Electrical Characteristics

#### Table 7 (1 / 3)

(V1 = V2 = V3 = V4 = V5 = 3.5 V, Ta = +25°C unless otherwise specified)

<table>
<thead>
<tr>
<th>Item</th>
<th>Symbol</th>
<th>Condition</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Test Circuit</th>
</tr>
</thead>
<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 n (n = 1 to 5)</td>
<td>VCUn</td>
<td>V1 = V2 = V3 = V4 = V5 = VCUH – 0.050 V</td>
<td>VCUH – 0.020</td>
<td>VCUH</td>
<td>VCUH + 0.020</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>Overcharge release voltage n (n = 1 to 5)</td>
<td>VCLn</td>
<td></td>
<td>VCLn – 0.050</td>
<td>VCLn</td>
<td>VCLn + 0.050</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>Overdischarge detection voltage n (n = 1 to 5)</td>
<td>VDLn</td>
<td></td>
<td>VDLn – 0.080</td>
<td>VDLn</td>
<td>VDLn + 0.080</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>Overdischarge release voltage n (n = 1 to 5)</td>
<td>VDUn</td>
<td></td>
<td>VDUn – 0.100</td>
<td>VDUn</td>
<td>VDUn + 0.100</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>Discharge overcurrent 1 detection voltage</td>
<td>VDIOV1</td>
<td></td>
<td>VDIOV1 – 0.010</td>
<td>VDIOV1</td>
<td>VDIOV1 + 0.010</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>Discharge overcurrent 2 detection voltage</td>
<td>VDIOV2</td>
<td></td>
<td>VDIOV2 – 0.015</td>
<td>VDIOV2</td>
<td>VDIOV2 + 0.015</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>Load short-circuiting detection voltage</td>
<td>VSHORT</td>
<td></td>
<td>VSHORT – 0.050</td>
<td>VSHORT</td>
<td>VSHORT + 0.050</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>Charge overcurrent detection voltage</td>
<td>VCIOV</td>
<td></td>
<td>VCIOV – 0.010</td>
<td>VCIOV</td>
<td>VCIOV + 0.010</td>
<td>V</td>
<td>1</td>
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</tbody>
</table>

#### Delay Time Function*1

<table>
<thead>
<tr>
<th>Item</th>
<th>Symbol</th>
<th>Condition</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Test Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCT pin internal resistance</td>
<td>R_CCT</td>
<td>V1 = VCU + 0.025</td>
<td>6.15</td>
<td>8.31</td>
<td>10.20</td>
<td>MΩ</td>
<td>1</td>
</tr>
<tr>
<td>CDT pin internal resistance</td>
<td>R_CDT</td>
<td>V1 = VDL – 0.085</td>
<td>615</td>
<td>831</td>
<td>1020</td>
<td>kΩ</td>
<td>1</td>
</tr>
<tr>
<td>CIT pin internal resistance</td>
<td>R_CIT</td>
<td>R_CIT = 831 kΩ</td>
<td>615</td>
<td>831</td>
<td>1020</td>
<td>kΩ</td>
<td>1</td>
</tr>
<tr>
<td>CIT2 pin internal resistance</td>
<td>R_CIT2</td>
<td></td>
<td>123</td>
<td>166</td>
<td>204</td>
<td>kΩ</td>
<td>1</td>
</tr>
<tr>
<td>CICT pin internal resistance</td>
<td>R_CICT</td>
<td></td>
<td>123</td>
<td>166</td>
<td>204</td>
<td>kΩ</td>
<td>1</td>
</tr>
<tr>
<td>CCT pin detection voltage</td>
<td>V_CCT</td>
<td>V1 = VCU + 0.025</td>
<td>VDS × 0.68</td>
<td>VDS × 0.70</td>
<td>VDS × 0.72</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>CDT pin detection voltage</td>
<td>V_CDT</td>
<td>V1 = VDL – 0.085</td>
<td>VDS × 0.68</td>
<td>VDS × 0.70</td>
<td>VDS × 0.72</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>CIT pin detection voltage</td>
<td>V_CIT</td>
<td></td>
<td>VDS × 0.68</td>
<td>VDS × 0.70</td>
<td>VDS × 0.72</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>CIT2 pin detection voltage</td>
<td>V_CIT2</td>
<td></td>
<td>VDS × 0.68</td>
<td>VDS × 0.70</td>
<td>VDS × 0.72</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>CICT pin detection voltage</td>
<td>V_CICT</td>
<td></td>
<td>VDS × 0.68</td>
<td>VDS × 0.70</td>
<td>VDS × 0.72</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>Load short-circuiting detection delay time</td>
<td>tSHORT</td>
<td>Internally fixed delay time</td>
<td>100</td>
<td>300</td>
<td>600</td>
<td>µs</td>
<td>1</td>
</tr>
</tbody>
</table>

#### Input Voltage

| Operation voltage between VDD pin and VSS pin | V_DSOP | Fixed output voltage of DO pin and CO pin | 5 | – | 24 | V | – |

*1. Refer to "6. Delay time setting" in "■ Operation" for details of the delay time function.
### Table 7 (2 / 3)

(V1 = V2 = V3 = V4 = V5 = 3.5 V, Ta = +25°C unless otherwise specified)

<table>
<thead>
<tr>
<th>Item</th>
<th>Symbol</th>
<th>Condition</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Test Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input Current</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current consumption during operation</td>
<td>IOPE</td>
<td>–</td>
<td>–</td>
<td>10</td>
<td>20</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>Current consumption during power-down</td>
<td>IPDN</td>
<td>V1 = V2 = V3 = V4 = V5 = 1.5 V</td>
<td>–</td>
<td>–</td>
<td>0.5</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>Current consumption during power-saving</td>
<td>ISBV</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0.1</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>VC1 pin current</td>
<td>IVC1</td>
<td>–</td>
<td>–</td>
<td>0.25</td>
<td>0.50</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>VC2 pin current</td>
<td>IVC2</td>
<td>–</td>
<td>–</td>
<td>–0.8</td>
<td>0.0</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>VC3 pin current</td>
<td>IVC3</td>
<td>–</td>
<td>–</td>
<td>–0.8</td>
<td>0.0</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>VC4 pin current</td>
<td>IVC4</td>
<td>–</td>
<td>–</td>
<td>–0.8</td>
<td>0.0</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>VC5 pin current</td>
<td>IVC5</td>
<td>–</td>
<td>–</td>
<td>–0.8</td>
<td>0.0</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td><strong>Internal Resistance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistance between VM pin and VDD pin</td>
<td>RVMD</td>
<td>V1 = V2 = V3 = V4 = V5 = 1.5 V</td>
<td>1.35</td>
<td>2.70</td>
<td>5.40</td>
<td>MΩ</td>
<td>1</td>
</tr>
<tr>
<td>Resistance between VM pin and VSS pin</td>
<td>RVMSS</td>
<td>–</td>
<td>–</td>
<td>7.5</td>
<td>15.0</td>
<td>30.0 kΩ</td>
<td>1</td>
</tr>
<tr>
<td><strong>Output Pin</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO pin voltage <em>H</em>¹</td>
<td>VCOH</td>
<td>VCOH &lt; VDS</td>
<td>11.0</td>
<td>13.0</td>
<td>15.0</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>DO pin voltage <em>H</em>²</td>
<td>VDOH</td>
<td>VDOH &lt; VDS</td>
<td>11.0</td>
<td>13.0</td>
<td>15.0</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>CO pin source current</td>
<td>ICOH</td>
<td>–</td>
<td>10</td>
<td>–</td>
<td>–</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>DO pin source current</td>
<td>IDCOH</td>
<td>–</td>
<td>10</td>
<td>–</td>
<td>–</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>CO pin leakage current</td>
<td>ICOL</td>
<td>V1 = V2 = V3 = V4 = V5 = 5.6 V</td>
<td>–</td>
<td>–</td>
<td>0.1</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>DO pin sink current</td>
<td>IDOL</td>
<td>–</td>
<td>10</td>
<td>–</td>
<td>–</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>PSO pin source current</td>
<td>IPSOH</td>
<td>–</td>
<td>10</td>
<td>–</td>
<td>–</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>PSO pin sink current</td>
<td>IPSOL</td>
<td>V1 = V2 = V3 = V4 = V5 = 1.9 V</td>
<td>10</td>
<td>–</td>
<td>–</td>
<td>μA</td>
<td>1</td>
</tr>
</tbody>
</table>

**0 V Battery Charge Function**

| 0 V battery charge starting charger voltage | VCHA   | 0 V battery charge function *available*, V1 = V2 = V3 = V4 = V5 = 0 V | – | 0.8 | 1.5 | V | 1 |
| 0 V battery charge inhibition battery voltage n (n = 1 to 5) | VINHn  | 0 V battery charge function *unavailable* | 1.0 | 1.3 | 1.5 | V | 1 |

*1. When VCOH ≥ VDS, VCOH = VDD
*2. When VDOH ≥ VDS, VDOH = VDD

**Remark**

VDS: Input voltage between the VDD pin and VSS pin (V1 + V2 + V3 + V4 + V5)
### Table 7 (3 / 3)

(V1 = V2 = V3 = V4 = V5 = 3.5 V, Ta = +25°C unless otherwise specified)

<table>
<thead>
<tr>
<th>Item</th>
<th>Symbol</th>
<th>Condition</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Test Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control Pin</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEL1 pin voltage &quot;H&quot;</td>
<td>VSEL1H</td>
<td>–</td>
<td>VDS × 0.95</td>
<td>–</td>
<td>–</td>
<td>V</td>
<td>–</td>
</tr>
<tr>
<td>SEL2 pin voltage &quot;H&quot;</td>
<td>VSEL2H</td>
<td>–</td>
<td>VDS × 0.95</td>
<td>–</td>
<td>–</td>
<td>V</td>
<td>–</td>
</tr>
<tr>
<td>SEL1 pin voltage &quot;L&quot;</td>
<td>VSEL1L</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>VDS × 0.05</td>
<td>V</td>
<td>–</td>
</tr>
<tr>
<td>SEL2 pin voltage &quot;L&quot;</td>
<td>VSEL2L</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>VDS × 0.05</td>
<td>V</td>
<td>–</td>
</tr>
<tr>
<td>CTLC pin reverse voltage</td>
<td>VCTLC</td>
<td>–</td>
<td>0.1</td>
<td>0.7</td>
<td>2.0</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>CTLD pin reverse voltage</td>
<td>VCTLD</td>
<td>–</td>
<td>0.1</td>
<td>0.7</td>
<td>2.0</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>PSI pin reverse voltage</td>
<td>VPSI</td>
<td>–</td>
<td>0.1</td>
<td>4.0</td>
<td>8.0</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>CTLC pin response delay time</td>
<td>tCTLC</td>
<td>–</td>
<td>0.275</td>
<td>0.500</td>
<td>0.725</td>
<td>ms</td>
<td>1</td>
</tr>
<tr>
<td>CTLD pin response delay time</td>
<td>tCTLD</td>
<td>–</td>
<td>0.275</td>
<td>0.500</td>
<td>0.725</td>
<td>ms</td>
<td>1</td>
</tr>
<tr>
<td>PSI pin response delay time</td>
<td>tPSI</td>
<td>–</td>
<td>0.3</td>
<td>0.9</td>
<td>3.0</td>
<td>ms</td>
<td>1</td>
</tr>
<tr>
<td>CTLC pin current &quot;H&quot;</td>
<td>ICTLCH</td>
<td>–</td>
<td>–0.1</td>
<td>0.0</td>
<td>0.1</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>CTLC pin current &quot;L&quot;</td>
<td>ICTLCL</td>
<td>–</td>
<td>–0.45</td>
<td>–0.20</td>
<td>–0.05</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>CTLD pin current &quot;H&quot;</td>
<td>ICTLDH</td>
<td>–</td>
<td>–0.1</td>
<td>0.0</td>
<td>0.1</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>CTLD pin current &quot;L&quot;</td>
<td>ICTLDL</td>
<td>–</td>
<td>–0.45</td>
<td>–0.20</td>
<td>–0.05</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>PSI pin current &quot;H&quot;</td>
<td>IPSIH</td>
<td>–</td>
<td>0.0</td>
<td>0.2</td>
<td>0.4</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>PSI pin current &quot;L&quot;</td>
<td>IPSIL</td>
<td>–</td>
<td>–0.1</td>
<td>0.0</td>
<td>0.1</td>
<td>μA</td>
<td>1</td>
</tr>
<tr>
<td>CTLC pin reverse voltage during communication</td>
<td>VCTLC_C</td>
<td>5.1 MΩ resistance connected to the CTLC pin</td>
<td>VDS + 0.2</td>
<td>VDS + 0.7</td>
<td>VDS + 1.3</td>
<td>V</td>
<td>3</td>
</tr>
<tr>
<td>CTLD pin reverse voltage during communication</td>
<td>VCTLD_C</td>
<td>5.1 MΩ resistance connected to the CTLD pin</td>
<td>VDS + 0.2</td>
<td>VDS + 0.7</td>
<td>VDS + 1.3</td>
<td>V</td>
<td>3</td>
</tr>
<tr>
<td>PSI pin reverse voltage during communication</td>
<td>VPSI_C</td>
<td>5.1 MΩ resistance connected to the PSI pin</td>
<td>VSS – 1.9</td>
<td>VSS – 1.0</td>
<td>VSS – 0.3</td>
<td>V</td>
<td>3</td>
</tr>
<tr>
<td><strong>Temperature Detection Function</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output voltage for temperature detection</td>
<td>VREG</td>
<td>Voltage between VDD pin and VREG pin</td>
<td>4.0</td>
<td>5.0</td>
<td>6.0</td>
<td>V</td>
<td>2</td>
</tr>
<tr>
<td>High temperature detection ratio during charging</td>
<td>fTHCH</td>
<td>fTHCH = (VREG – VTH) / VREG</td>
<td>fTHCH – 0.005</td>
<td>fTHCH + 0.005</td>
<td>–</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Low temperature detection ratio during charging</td>
<td>fTHCL</td>
<td>fTHCL = (VREG – VTH) / VREG</td>
<td>fTHCL – 0.005</td>
<td>fTHCL + 0.005</td>
<td>–</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>High temperature detection ratio during discharging</td>
<td>fTHDH</td>
<td>fTHDH = (VREG – VTH) / VREG</td>
<td>fTHDH – 0.005</td>
<td>fTHDH + 0.005</td>
<td>–</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Low temperature detection ratio during discharging</td>
<td>fTHDL</td>
<td>fTHDL = (VREG – VTH) / VREG</td>
<td>fTHDL – 0.005</td>
<td>fTHDL + 0.005</td>
<td>–</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Charge-discharge discriminating voltage</td>
<td>VCHG</td>
<td>–</td>
<td>–0.03</td>
<td>–0.02</td>
<td>–0.01</td>
<td>V</td>
<td>2</td>
</tr>
<tr>
<td>Temperature detection delay time</td>
<td>tTH</td>
<td>–</td>
<td>1.0</td>
<td>2.0</td>
<td>3.0</td>
<td>s</td>
<td>2</td>
</tr>
</tbody>
</table>
Test Circuits

Unless otherwise specified, for the CO pin output voltage (V_{CO}), DO pin output voltage (V_{DO}), and PSO pin output voltage (V_{PSO}), "L" or "H" is judged as follows.

- **L**: \([V_{CO}, V_{DO}, V_{PSO}] \leq V_{DS} \times 0.1 \, \text{V}\)
- **H**: \([V_{CO}, V_{DO}, V_{PSO}] > V_{DS} \times 0.1 \, \text{V}\)

**Remark**: \(V_{DS}\): Input voltage between the VDD pin and VSS pin (\(V_{1} + V_{2} + V_{3} + V_{4} + V_{5}\))

1. Test circuit 1

![Test Circuit 1 Diagram]

**Figure 3 Test Circuit 1**

This section provides explanations of Test items using Test circuit 1. Perform each test after setting as shown in **Table 8**.

<table>
<thead>
<tr>
<th>(V_{1})</th>
<th>(V_{2})</th>
<th>(V_{3})</th>
<th>(V_{4})</th>
<th>(V_{5})</th>
<th>(V_{6})</th>
<th>(V_{7})</th>
<th>(V_{8})</th>
<th>(V_{9})</th>
<th>(V_{10})</th>
<th>(V_{11})</th>
<th>(V_{12})</th>
<th>(V_{13})</th>
<th>(V_{14})</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5 , \text{V}</td>
<td>3.5 , \text{V}</td>
<td>3.5 , \text{V}</td>
<td>3.5 , \text{V}</td>
<td>3.5 , \text{V}</td>
<td>0 , \text{V}</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

**Table 8 Initial Setting of Test Circuit 1 (1 / 2)**

<table>
<thead>
<tr>
<th>(V_{15})</th>
<th>(V_{16})</th>
<th>(V_{17})</th>
<th>(V_{18})</th>
<th>(\text{SW}1)</th>
<th>(\text{SW}2)</th>
<th>(\text{SW}3)</th>
<th>(\text{SW}4)</th>
<th>(\text{SW}5)</th>
<th>(\text{SW}6)</th>
<th>(\text{SW}7)</th>
<th>(\text{SW}8)</th>
<th>(\text{SW}9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 , \text{V}</td>
<td>0 , \text{V}</td>
<td>0 , \text{V}</td>
<td>(V_{DS})</td>
<td>\text{OFF}</td>
<td>\text{OFF}</td>
<td>\text{OFF}</td>
<td>\text{OFF}</td>
<td>\text{OFF}</td>
<td>\text{OFF}</td>
<td>\text{OFF}</td>
<td>\text{ON}</td>
<td>\text{OFF}</td>
</tr>
</tbody>
</table>

**Table 8 Initial Setting of Test Circuit 1 (2 / 2)**
1.1 Overcharge detection voltage \( n (V_{CUn}) \), overcharge release voltage \( n (V_{CLn}) \)

When the voltage \( V_1 \) is gradually increased after setting \( V_1 = V_2 = V_3 = V_4 = V_5 = V_{CUn} - 0.05 \) V and \( V_{CO} \) changes from "H" to "L", \( V_1 \) is defined as the overcharge detection voltage \( 1 (V_{CU1}) \). When the voltage \( V_1 \) is then gradually decreased after setting \( V_2 = V_3 = V_4 = V_5 = 3.5 \) V and \( V_{15} = -5 \) mV and \( V_{CO} \) changes from "L" to "H", \( V_1 \) is defined as the overcharge release voltage \( 1 (V_{CL1}) \).

Overcharge detection voltage \( n (V_{CUn}) \) and overcharge release voltage \( n (V_{CLn}) \) \( (n = 2 \) to 5) can be determined in the same way as when \( n = 1 \).

1.2 Overdischarge detection voltage \( n (V_{DLn}) \), overdischarge release voltage \( n (V_{DUn}) \)

When the voltage \( V_1 \) is gradually decreased and \( V_{DO} \) changes from "H" to "L", \( V_1 \) is defined as the overdischarge detection voltage \( 1 (V_{DL1}) \). When the voltage \( V_1 \) is then gradually increased after setting \( V_{15} = 0.1 \) V and \( V_{DO} \) changes from "L" to "H", \( V_1 \) is defined as the overdischarge release voltage \( 1 (V_{DUI1}) \).

Overdischarge detection voltage \( n (V_{DLn}) \) and overdischarge release voltage \( n (V_{DUn}) \) \( (n = 2 \) to 5) can be determined in the same way as when \( n = 1 \).

1.3 Discharge overcurrent 1 detection voltage \( (V_{DIOV1}) \)

When the voltage \( V_6 \) is gradually increased and \( V_{DO} \) changes from "H" to "L", \( V_6 \) is defined as the discharge overcurrent 1 detection voltage \( (V_{DIOV1}) \).

1.4 Discharge overcurrent 2 detection voltage \( (V_{DIOV2}) \)

When the voltage \( V_6 \) is gradually increased after setting \( V_{10} = 0 \) V and \( SW_4 \) to ON and \( V_{DO} \) changes from "H" to "L", \( V_6 \) is defined as the discharge overcurrent 2 detection voltage \( (V_{DIOV2}) \).

1.5 Load short-circuiting detection voltage \( (V_{SHORT}) \)

When the voltage \( V_6 \) is gradually increased after setting \( V_{10} = V_{11} = 0 \) V and \( SW_4 \) and \( SW_5 \) to ON and \( V_{DO} \) changes from "H" to "L", \( V_6 \) is defined as the load short-circuiting detection voltage \( (V_{SHORT}) \).

1.6 Charge overcurrent detection voltage \( (V_{CIOV}) \)

When the voltage \( V_6 \) is gradually decreased and \( V_{CO} \) changes from "H" to "L", \( V_6 \) is defined as the charge overcurrent detection voltage \( (V_{CIOV}) \).

1.7 CCT pin internal resistance \( (R_{CCT}) \), CCT pin detection voltage \( (V_{CCT}) \)

The CCT pin internal resistance \( (R_{CCT}) \) is defined by \( R_{CCT} = V_{DS} / I_{CCT} \) under the set conditions of \( V_1 = V_{CUI} + 0.025 \) V after setting \( V_8 = 0 \) V and setting \( SW_2 \) to ON. When the voltage \( V_8 \) is then gradually increased and \( V_{CO} \) changes from "H" to "L", \( V_8 \) is defined as the CCT pin detection voltage \( (V_{CCT}) \).

1.8 CDT pin internal resistance \( (R_{CDT}) \), CDT pin detection voltage \( (V_{CDT}) \)

The CDT pin internal resistance \( (R_{CDT}) \) is defined by \( R_{CDT} = V_{DS} / I_{CDT} \) under the set conditions of \( V_1 = V_{DL1} - 0.085 \) V after setting \( V_9 = 0 \) V and setting \( SW_3 \) to ON. When the voltage \( V_9 \) is then gradually increased and \( V_{DO} \) changes from "H" to "L", \( V_9 \) is defined as the CDT pin detection voltage \( (V_{CDT}) \).

1.9 CIT pin internal resistance \( (R_{CIT}) \), CIT pin detection voltage \( (V_{CIT}) \)

The CIT pin internal resistance \( (R_{CIT}) \) is defined by \( R_{CIT} = V_{DS} / I_{CIT} \) under the set conditions of \( V_6 = V_{DOV1} + 0.015 \) V after setting \( V_{10} = 0 \) V and setting \( SW_4 \) to ON. When the voltage \( V_{10} \) is then gradually increased and \( V_{DO} \) changes from "H" to "L", \( V_{10} \) is defined as the CIT pin detection voltage \( (V_{CIT}) \).

1.10 CIT2 pin internal resistance \( (R_{CIT2}) \), CIT2 pin detection voltage \( (V_{CIT2}) \)

The CIT2 pin internal resistance \( (R_{CIT2}) \) is defined by \( R_{CIT2} = V_{DS} / I_{CIT2} \) under the set conditions of \( V_6 = V_{DOV2} + 0.020 \) V after setting \( V_{10} = V_{11} = 0 \) V and setting \( SW_4 \) and \( SW_5 \) to ON. When the voltage \( V_{11} \) is then gradually increased and \( V_{DO} \) changes from "H" to "L", \( V_{11} \) is defined as the CIT2 pin detection voltage \( (V_{CIT2}) \).

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1.11 CICT pin internal resistance ($R_{CICT}$), CICT pin detection voltage ($V_{CICT}$)

The CICT pin internal resistance ($R_{CICT}$) is defined by $R_{CICT} = V_{DS} / I_{CICT}$ under the set conditions of $V6 = V_{CIOV} - 0.015$ V after setting $V7 = 0$ V and setting SW1 to ON. When the voltage $V7$ is then gradually increased and $V_{CO}$ changes from "H" to "L", $V7$ is defined as the CICT pin detection voltage ($V_{CICT}$).

1.12 Load short-circuiting detection delay time ($t_{SHORT}$)

The load short-circuiting detection delay time ($t_{SHORT}$) is the time period from when the voltage $V6$ changes to $V6 = V_{SHORT} + 0.055$ V until when $V_{DO}$ changes from "H" to "L" after setting $V10 = V11 = 0$ V and setting SW4 and SW5 to ON.

1.13 Current consumption during operation ($I_{OP}$)

The current consumption during operation ($I_{OP}$) is $I_{VSS}$ when SW8 is OFF.

1.14 Current consumption during power-down ($I_{PD}$)

The current consumption during power-down ($I_{PD}$) is $I_{VSS}$ when $V1 = V2 = V3 = V4 = V5 = 1.5$ V, $V15 = V_{DS}$ and SW8 is OFF.

1.15 Current consumption during power-saving ($I_{PS}$)

The current consumption during power-saving ($I_{PS}$) is $I_{VSS}$ when $V18 = 0$ V and SW8 is OFF.

1.16 Resistance between VM pin and VDD pin ($R_{VMD}$)

The resistance between VM pin and VDD pin ($R_{VMD}$) is defined by $R_{VMD} = V_{DS} / I_{VM}$ when setting $V1 = V2 = V3 = V4 = V5 = 1.5$ V.

1.17 Resistance between VM pin and VSS pin ($R_{VMS}$)

The resistance between VM pin and VSS pin ($R_{VMS}$) is defined by $R_{VMS} = V15 / I_{VM}$ when setting $V6 = V_{DIOV1} + 0.015$ V and $V15 = 2.0$ V.

1.18 CO pin source current ($I_{COH}$)

The CO pin source current ($I_{COH}$) is $I_{CO}$ when $V14 = V_{COH} - 0.5$ V, SW8 is OFF, and SW9 is ON.

1.19 CO pin leakage current ($I_{COL}$)

The CO pin leakage current ($I_{COL}$) is $I_{CO}$ when $V1 = V2 = V3 = V4 = V5 = 5.6$ V, $V14 = 0$ V, SW8 is OFF, and SW9 is ON.

1.20 DO pin source current ($I_{DOH}$)

The DO pin source current ($I_{DOH}$) is $I_{DO}$ when $V13 = V_{DOH} - 0.5$ V and SW7 is ON.

1.21 DO pin sink current ($I_{DOL}$)

The DO pin sink current ($I_{DOL}$) is $I_{DO}$ when $V1 = V2 = V3 = V4 = V5 = 1.9$ V, $V13 = 0.5$ V, and SW7 is ON.

1.22 PSO pin source current ($I_{PSOH}$)

The PSO pin source current ($I_{PSOH}$) is $I_{PSO}$ when $V18 = 0$ V, $V12 = V_{DS} - 0.5$ V, and SW6 is ON.

1.23 PSO pin sink current ($I_{PSOL}$)

The PSO pin sink current ($I_{PSOL}$) is $I_{PSO}$ when $V12 = 0.5$ V and SW6 is ON.
1.24 0 V battery charge starting charger voltage \( (V_{\text{CHA}}) \) (0 V battery charge function "available")

When the voltage \( V_{15} \) is gradually decreased after setting \( V_{1} = V_{2} = V_{3} = V_{4} = V_{5} = 0 \) V and \( V_{CO} \) is "H", the absolute value of \( V_{15} \) is defined as the 0 V battery charge starting charger voltage \( (V_{\text{CHA}}) \).

1.25 0 V battery charge inhibition battery voltage n \( (V_{\text{INHn}}) \) (0 V battery charge function "unavailable")

When the voltage \( V_{1} \) is gradually decreased and \( V_{CO} \) changes from "H" to "L", \( V_{1} \) is defined as the 0 V battery charge inhibition battery voltage \( 1 \) \( (V_{\text{INH1}}) \).

0 V battery charge inhibition battery voltage n \( (V_{\text{INHn}}) \) \( (n = 2 \text{ to } 5) \) can be determined in the same way as when \( n = 1 \).

1.26 CTLC pin reverse voltage \( (V_{\text{CTLC}}) \)

When the voltage \( V_{16} \) is gradually increased and \( V_{CO} \) changes from "H" to "L", \( V_{16} \) is defined as the CTLC pin reverse voltage \( (V_{\text{CTLC}}) \).

1.27 CTLD pin reverse voltage \( (V_{\text{CTLD}}) \)

When the voltage \( V_{17} \) is gradually increased and \( V_{DO} \) changes from "H" to "L", \( V_{17} \) is defined as the CTLD pin reverse voltage \( (V_{\text{CTLD}}) \).

1.28 PSI pin reverse voltage \( (V_{\text{PSI}}) \)

When the voltage \( V_{18} \) is gradually decreased and \( V_{PSO} \) changes from "L" to "H", \( V_{18} \) is defined as the PSI pin reverse voltage \( (V_{\text{PSI}}) \).

1.29 CTLC pin response delay time \( (t_{\text{CTLC}}) \)

The CTLC pin response delay time \( (t_{\text{CTLC}}) \) is the time period from when the voltage \( V_{16} \) changes to \( V_{16} = V_{DS} \) until when \( V_{CO} \) changes from "H" to "L".

1.30 CTLD pin response delay time \( (t_{\text{CTLD}}) \)

The CTLD pin response delay time \( (t_{\text{CTLD}}) \) is the time period from when the voltage \( V_{17} \) changes to \( V_{17} = V_{DS} \) until when \( V_{DO} \) changes from "H" to "L".

1.31 PSI pin response delay time \( (t_{\text{PSI}}) \)

The PSI pin response delay time \( (t_{\text{PSI}}) \) is the time period from when the voltage \( V_{18} \) changes to \( V_{18} = 0 \) V until when \( V_{PSO} \) changes from "L" to "H".

1.32 CTLC pin current "H" \( (I_{\text{CTLCH}}) \), CTLC pin current "L" \( (I_{\text{CTLC}}) \)

The CTLC pin current "H" \( (I_{\text{CTLCH}}) \) is \( I_{\text{CTLC}} \) when \( V_{16} = V_{DS} \).

The CTLC pin current "L" \( (I_{\text{CTLC}}) \) is \( I_{\text{CTLC}} \) when \( V_{16} = 0 \) V.

1.33 CTLD pin current "H" \( (I_{\text{CTLDH}}) \), CTLD pin current "L" \( (I_{\text{CTLDL}}) \)

The CTLD pin current "H" \( (I_{\text{CTLDH}}) \) is \( I_{\text{CTLD}} \) when \( V_{17} = V_{DS} \).

The CTLD pin current "L" \( (I_{\text{CTLDL}}) \) is \( I_{\text{CTLD}} \) when \( V_{17} = 0 \) V.

1.34 PSI pin current "H" \( (I_{\text{PSIH}}) \), PSI pin current "L" \( (I_{\text{PSIL}}) \)

The PSI pin current "H" \( (I_{\text{PSIH}}) \) is \( I_{\text{PSI}} \) when \( V_{18} = V_{DS} \).

The PSI pin current "L" \( (I_{\text{PSIL}}) \) is \( I_{\text{PSI}} \) when \( V_{18} = 0 \) V.
2. Test circuit 2

![Test Circuit 2 Diagram]

This section provides explanations of Test items using Test circuit 2. Perform each test after setting as shown in Table 9.

Table 9   Initial Setting of Test Circuit 2

<table>
<thead>
<tr>
<th>V1</th>
<th>V2</th>
<th>V3</th>
<th>V4</th>
<th>V5</th>
<th>V6</th>
<th>V7*1</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5 V</td>
<td>3.5 V</td>
<td>3.5 V</td>
<td>3.5 V</td>
<td>3.5 V</td>
<td>0 V</td>
<td>2.5 V</td>
</tr>
</tbody>
</table>

*1. V7 is an absolute value.

2.1 Output voltage for temperature detection (V\text{REG})

The maximum voltage between the VDD pin and VREG pin is defined as the output voltage for temperature detection (V\text{REG}).

2.2 High temperature detection ratio during charging (r\text{THCH})

When the voltage V7 is gradually decreased after setting V6 = −0.03 V and V\text{CO} changes from "H" to "L" and V\text{DO} changes from "H" to "L", the high temperature detection ratio during charging (r\text{THCH}) is defined by (V\text{REG} − V7) / V\text{REG}.

2.3 Low temperature detection ratio during charging (r\text{THCL})

When the voltage V7 is gradually increased after setting V6 = −0.03 V and V\text{CO} changes from "H" to "L" and V\text{DO} changes from "H" to "L", the low temperature detection ratio during charging (r\text{THCL}) is defined by (V\text{REG} − V7) / V\text{REG}.

2.4 High temperature detection ratio during discharging (r\text{THDH})

When the voltage V7 is gradually decreased and V\text{CO} changes from "H" to "L" and V\text{DO} changes from "H" to "L", the high temperature detection ratio during discharging (r\text{THDH}) is defined by (V\text{REG} − V7) / V\text{REG}.

2.5 Low temperature detection ratio during discharging (r\text{THDL})

When the voltage V7 is gradually increased and V\text{CO} changes from "H" to "L" and V\text{DO} changes from "H" to "L", the low temperature detection ratio during discharging (r\text{THDL}) is defined by (V\text{REG} − V7) / V\text{REG}.
2.6 Charge-discharge discriminating voltage (V\text{CHG})

When the voltage V6 is gradually decreased after setting \((1 - \text{rTHDH}) \times V_{\text{REG}} < V7 < (1 - \text{rTHCH}) \times V_{\text{REG}}\) and \(V_{\text{CO}}\) changes from "H" to "L", and \(V_{\text{DO}}\) changes from "H" to "L", V6 is defined as the charge-discharge discriminating voltage (V\text{CHG}).

2.7 Temperature detection delay time (t\text{TH})

The temperature detection delay time (t\text{TH}) is the time period from when the voltage V7 changes to 0 V until when \(V_{\text{CO}}\) changes from "H" to "L", and \(V_{\text{DO}}\) changes from "H" to "L".

3. Test circuit 3

![Test Circuit 3 Diagram]

This section provides explanations of Test items using Test circuit 3. Perform each test after setting as shown in Table 10.

<table>
<thead>
<tr>
<th>Table 10</th>
<th>Initial Setting of Test Circuit 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V1</td>
</tr>
<tr>
<td></td>
<td>3.5 V</td>
</tr>
</tbody>
</table>

3.1 CTLC pin reverse voltage during communication (V\text{CTLC}_c)

When the voltage V6 is gradually decreased and \(V_{\text{CO}}\) changes from "H" to "L", V6 is defined as the CTLC pin reverse voltage during communication (V\text{CTLC}_c).

3.2 CTLD pin reverse voltage during communication (V\text{CTLD}_c)

When the voltage V7 is gradually decreased and \(V_{\text{DO}}\) changes from "H" to "L", V7 is defined as the CTLD pin reverse voltage during communication (V\text{CTLD}_c).

3.3 PSI pin reverse voltage during communication (V\text{PSI}_c)

When the voltage V8 is gradually increased and \(V_{\text{PSO}}\) changes from "L" to "H", V8 is defined as the PSI pin reverse voltage during communication (V\text{PSI}_c).
Operation

Remark Refer to "Connection Examples of Battery Protection IC".

1. Normal status

The status when the CO pin output voltage (V_{CO}) = "H", DO pin output voltage (V_{DO}) = "H", and PSO pin output voltage (V_{PSO}) = "L" is the normal status. All the conditions mentioned below should be satisfied for returning to the normal status.

- The voltage of each of the batteries is in the range from the overcharge detection voltage n \( (V_{CUn}) \) to overdischarge detection voltage n \( (V_{DUn}) \).
- The VINI pin voltage is in the range of the charge overcurrent detection voltage \( (V_{CIOV}) \) to discharge overcurrent 1 detection voltage \( (V_{DIOV1}) \).
- The CTLC pin voltage and CTLD pin voltage are lower than the CTLC pin reverse voltage \( (V_{CTLC}) \) and CTLD pin reverse voltage \( (V_{CTLD}) \), respectively, and the PSI pin voltage is higher than the PSI pin reverse voltage \( (V_{PSI}) \).
- Either (1) or (2) below is satisfied for the TH pin voltage \( (V_{TH}) \).

\[
\begin{align*}
(1) & \quad \text{When } V_{VM} \leq V_{CHG}: \quad (1 - r_{THCH}) \times V_{REG} < V_{TH} < (1 - r_{THCL}) \times V_{REG} \\
(2) & \quad \text{When } V_{VM} > V_{CHG}: \quad (1 - r_{THDH}) \times V_{REG} < V_{TH} < (1 - r_{THDL}) \times V_{REG}
\end{align*}
\]

Caution After a battery is connected, there may be cases when discharging cannot be performed. In this case, the S-8245A/C Series returns to the normal status when any of the following conditions is satisfied.

(1) Connecting a charger
(2) Shorting between the VM pin and the VSS pin
(3) Changing the PSI pin voltage to be \( V_{DS} \rightarrow 0 \, \text{V} \rightarrow V_{DS} \)

Remark

- \( V_{VM} \): VM pin voltage
- \( V_{CHG} \): Charge-discharge discriminating voltage
- \( r_{THCH} \): High temperature detection ratio during charging
- \( r_{THCL} \): Low temperature detection ratio during charging
- \( r_{THDH} \): High temperature detection ratio during discharging
- \( r_{THDL} \): Low temperature detection ratio during discharging
- \( V_{REG} \): Output voltage for temperature detection
- \( V_{DS} \): Input voltage between the VDD pin and VSS pin \( (V1 + V2 + V3 + V4 + V5) \)

2. Overcharge status

When the voltage of any of the batteries exceeds the overcharge detection voltage n \( (V_{CUn}) \) and the status continues for the overcharge detection delay time \( (t_{CU}) \) or longer, the CO pin changes to high impedance. This is the overcharge status. The CO pin is pulled down to EB- by an external resistor so that the charge control FET is turned off to stop charging.

The overcharge status is released if either condition mentioned below is satisfied.

(1) \( V_{VM} < V_{DS} / 100 \), and voltage of battery \( \leq V_{CLn} \)
(2) \( V_{VM} \geq V_{DS} / 100 \), and voltage of all batteries \( \leq V_{CLn} \)

*1. Refer to "6. Delay time setting" for details.

Remark

- \( V_{VM} \): VM pin voltage
- \( V_{DS} \): Input voltage between the VDD pin and VSS pin \( (V1 + V2 + V3 + V4 + V5) \)
- \( V_{CUn} \): Overcharge detection voltage n \( (n = 1 \text{ to } 5) \)
- \( V_{CLn} \): Overcharge release voltage n \( (n = 1 \text{ to } 5) \)
3. Overdischarge status

When the voltage of any of the batteries falls below the overdischarge detection voltage \( n \) (\( V_{DLn} \)) and the status continues for the overdischarge detection delay time \( (t_{DL})^1 \) or longer, the DO pin changes to the VSS level. This is the overdischarge status. The discharge control FET is turned off to stop discharging.

The overdischarge status is released if either condition mentioned below is satisfied.

\[
\begin{align*}
(1) & \quad V_{VM} \leq V_{CHG}, \text{ and voltage of all batteries } \geq V_{DLn} \\
(2) & \quad V_{VM} > V_{CHG}, \text{ and voltage of battery } \geq V_{DUn}
\end{align*}
\]

*1. Refer to "6. Delay time setting" for details.

Remark
- \( V_{VM} \): VM pin voltage
- \( V_{CHG} \): Charge-discharge discriminating voltage
- \( V_{DLn} \): Overdischarge detection voltage \( n \) (\( n = 1 \) to \( 5 \))
- \( V_{DUn} \): Overdischarge release voltage \( n \) (\( n = 1 \) to \( 5 \))

3.1 With power-down function

When S-8245A/C Series reaches the overdischarge status, the VM pin is pulled up to the VDD level by a resistance between VM pin and VDD pin (\( R_{VM} \)). If the voltage difference between the VDD pin and the VM pin decreases to 1.0 V typ. or lower, the power-down function starts to operate and most operations in the S-8245A/C Series halt. In this case, the CO pin changes to high impedance, and the PSO pin changes to the VDD level.

The power-down function is released when the VM pin voltage changes to 0.7 V typ. or lower.

4. Discharge overcurrent status

When the discharge current increases to a certain value or more, the VINI pin voltage increases to the level of discharge overcurrent 1 detection voltage \( (V_{DIOV1}) \) or higher. If the status continues for the discharge overcurrent 1 detection delay time \( (t_{DIOV1})^1 \) or longer, the DO pin changes to the VSS level. This is the discharge overcurrent status. The discharge control FET is turned off to stop discharging. The VM pin is pulled down to the VSS level by resistance between VM pin and VSS pin (\( R_{VM} \)).

Discharge overcurrent is detected at the following three levels: \( V_{DIOV1} \), \( V_{DIOV2} \), and \( V_{SHORT} \). When discharge overcurrent 2 detection voltage \( (V_{DIOV2}) \) and load short-circuiting detection voltage \( (V_{SHORT}) \) are detected, the same operations as \( V_{DIOV1} \) detection are performed.

The discharge overcurrent status is released if the following conditions are satisfied.

- S-8245A Series: \( V_{VM} \leq V_{DS} / 4 \) typ.
- S-8245C Series: \( V_{VM} \leq V_{DS} / 5 \) typ.

*1. Refer to "6. Delay time setting" for details.

Remark
- \( V_{VM} \): VM pin voltage
- \( V_{DS} \): Input voltage between the VDD pin and VSS pin (\( V1 + V2 + V3 + V4 + V5 \))

5. Charge overcurrent status

When the charge current increases to a certain value or more, the VINI pin voltage decreases to the level of charge overcurrent detection voltage \( (V_{CIOV}) \) or lower. If the status continues for the charge overcurrent detection delay time \( (t_{CIOV})^1 \) or longer, the CO pin changes to high impedance. This is the charge overcurrent status. The charge control FET is turned off to stop charging.

The charge overcurrent status is released if \( V_{VM} \geq V_{DS} / 100 \) typ.

*1. Refer to "6. Delay time setting" for details.

Remark
- \( V_{VM} \): VM pin voltage
- \( V_{DS} \): Input voltage between the VDD pin and VSS pin (\( V1 + V2 + V3 + V4 + V5 \))
6. Delay time setting

Users are able to set delay time for the period from when the S-8245A/C Series detects change in the voltage of any of the batteries or the VIN1 pin until when it outputs to the CO pin or DO pin. Each delay time is determined by a resistor in the S-8245A/C Series and an external capacitor.

In the overcharge detection, when the voltage of any of the batteries exceeds overcharge detection voltage \( V_{CUn} \), the S-8245A/C Series starts charging to the CCT pin's capacitor \( C_{CCT} \) via the CCT pin internal resistance \( R_{CCT} \). After a certain period, the CO pin changes to high impedance when the CCT pin reaches the CCT pin detection voltage \( V_{CCT} \). This period is overcharge detection delay time \( t_{CU} \).

\[
t_{CU} \text{ [s]} = -\ln \left( 1 - \frac{V_{CCT}}{V_{DS}} \right) \times C_{CCT} [\mu F] \times R_{CCT} [M\Omega]
\]

\[
= -\ln \left( 1 - 0.7 \text{ typ.} \right) \times C_{CCT} [\mu F] \times 8.31 [M\Omega] \text{ typ.}
\]

\[
= 10.0 [M\Omega] \text{ typ.} \times C_{CCT} [\mu F]
\]

Overdischarge detection delay time \( t_{DL} \), discharge overcurrent 1 detection delay time \( t_{DIOV1} \), discharge overcurrent 2 detection delay time \( t_{DIOV2} \) and charge overcurrent detection delay time \( t_{CIOV} \) are calculated using the following equations as well.

\[
t_{DL} \text{ [ms]} = -\ln \left( 1 - \frac{V_{CDT}}{V_{DS}} \right) \times C_{CDT} [\mu F] \times R_{CDT} [k\Omega]
\]

\[
t_{DIOV1} \text{ [ms]} = -\ln \left( 1 - \frac{V_{CIT}}{V_{DS}} \right) \times C_{CIT} [\mu F] \times R_{CIT} [k\Omega]
\]

\[
t_{DIOV2} \text{ [ms]} = -\ln \left( 1 - \frac{V_{CIT2}}{V_{DS}} \right) \times C_{CIT2} [\mu F] \times R_{CIT2} [k\Omega]
\]

\[
t_{CIOV} \text{ [ms]} = -\ln \left( 1 - \frac{V_{CICT}}{V_{DS}} \right) \times C_{CICT} [\mu F] \times R_{CICT} [k\Omega]
\]

When \( C_{CCT} = C_{CDT} = C_{CIT} = C_{CIT2} = C_{CICT} = 0.1 [\mu F] \), each delay time is calculated as follows.

\[
t_{CU} \text{ [s]} = 10.0 [M\Omega] \text{ typ.} \times 0.1 [\mu F] = 1.0 [s] \text{ typ.}
\]

\[
t_{DL} \text{ [ms]} = 1000 [k\Omega] \text{ typ.} \times 0.1 [\mu F] = 100 [ms] \text{ typ.}
\]

\[
t_{DIOV1} \text{ [ms]} = 1000 [k\Omega] \text{ typ.} \times 0.1 [\mu F] = 100 [ms] \text{ typ.} \text{ (when } R_{CIT} = 831 k\Omega \text{ typ.)}
\]

\[
t_{DIOV2} \text{ [ms]} = 10.0 [M\Omega] \text{ typ.} \times 0.1 [\mu F] = 1.0 [s] \text{ typ.} \text{ (when } R_{CIT} = 8.31 M\Omega \text{ typ.)}
\]

\[
t_{CIOV} \text{ [ms]} = 200 [k\Omega] \text{ typ.} \times 0.1 [\mu F] = 20 [ms] \text{ typ.}
\]

Load short-circuiting detection delay time \( t_{SHORT} \) is fixed internally.

Remark \( V_{DS} \): Input voltage between the VDD pin and VSS pin (\( V_1 + V_2 + V_3 + V_4 + V_5 \))

7. 0 V Battery charge function

Regarding how to charge a self-discharged battery (0 V battery), users are able to select either function mentioned below.

(1) 0 V battery charge function “available”
A 0 V battery is charged when charger voltage is higher than \( V_{0CHA} \).

(2) 0 V battery charge function “unavailable”
A 0 V battery is not charged when the voltage of any of the batteries is \( V_{0INH} \) or lower.

Caution When the VDD pin voltage is lower than the minimum value of operation voltage between the VDD pin and VSS pin \( V_{DSOP} \), the S-8245A/C Series’ operation is not assured.

Remark \( V_{0CHA} \): 0 V battery charge starting charger voltage
\( V_{0INH} \): 0 V battery charge inhibition battery voltage \( n \) (\( n = 1 \) to 5)
8. SEL1 pin and SEL2 pin

Switching control for 3-serial to 5-serial cell is possible by inputting voltage to the SEL1 pin and the SEL2 pin. Be sure to use the SEL1 pin and the SEL2 pin at the "H" or "L" level.

<table>
<thead>
<tr>
<th>SEL1 Pin</th>
<th>SEL2 Pin</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;L&quot;</td>
<td>&quot;L&quot;</td>
<td>5-serial cell</td>
</tr>
<tr>
<td>&quot;L&quot;</td>
<td>&quot;H&quot;</td>
<td>4-serial cell</td>
</tr>
<tr>
<td>&quot;H&quot;</td>
<td>&quot;L&quot;</td>
<td>3-serial cell</td>
</tr>
<tr>
<td>&quot;H&quot;</td>
<td>&quot;H&quot;</td>
<td>Setting inhibited</td>
</tr>
</tbody>
</table>

Table 11  Settings of SEL1 Pin and SEL2 Pin

Remark  "H" is the status when $V_{SEL1} \geq V_{SEL1,H}$, $V_{SEL2} \geq V_{SEL2,H}$, and "L" is the status when $V_{SEL1} \leq V_{SEL1,L}$, $V_{SEL2} \leq V_{SEL2,L}$.

$V_{SEL1,H}$: SEL1 pin voltage "H"
$V_{SEL2,H}$: SEL2 pin voltage "H"
$V_{SEL1,L}$: SEL1 pin voltage "L"
$V_{SEL2,L}$: SEL2 pin voltage "L"

9. CTLC pin and CTLD pin

The CTLC pin controls the CO pin, and the CTLD pin controls the DO pin. Thus it is possible for users to control the CO pin and the DO pin respectively. These controls precede the battery protection circuit.

Table 12  Status Set by CTLC Pin

<table>
<thead>
<tr>
<th>CTLC Pin</th>
<th>CO Pin</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{SS}$ level $\leq$ CTLC pin voltage $&lt; V_{CTLC}$</td>
<td>&quot;H&quot;</td>
</tr>
<tr>
<td>$V_{CTLC} \leq$ CTLC pin voltage $\leq V_{DD}$ level</td>
<td>High impedance</td>
</tr>
<tr>
<td>$V_{DD}$ level $&lt;$ CTLC pin voltage $\leq V_{CTLC,C}$</td>
<td>High impedance</td>
</tr>
<tr>
<td>$V_{CTLC,C} &lt;$ CTLC pin voltage</td>
<td>&quot;H&quot;</td>
</tr>
</tbody>
</table>

Remark The CTLC pin is at the $V_{DD}$ level or higher in cascade connection. Connect a resistor of 5.1 M$\Omega$ to the CTLC pin in this case.

$V_{CTLC}$: CTLC pin reverse voltage
$V_{CTLC,C}$: CTLC pin reverse voltage during communication

Table 13  Status Set by CTLD Pin

<table>
<thead>
<tr>
<th>CTLD Pin</th>
<th>DO Pin</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{SS}$ level $\leq$ CTLD pin voltage $&lt; V_{CTLD}$</td>
<td>&quot;H&quot;</td>
</tr>
<tr>
<td>$V_{CTLD} \leq$ CTLD pin voltage $\leq V_{DD}$ level</td>
<td>$V_{SS}$ level</td>
</tr>
<tr>
<td>$V_{DD}$ level $&lt;$ CTLD pin voltage $\leq V_{CTLD,C}$</td>
<td>$V_{SS}$ level</td>
</tr>
<tr>
<td>$V_{CTLD,C} &lt;$ CTLD pin voltage</td>
<td>&quot;H&quot;</td>
</tr>
</tbody>
</table>

Remark The CTLD pin is at the $V_{DD}$ level or higher in cascade connection. Connect a resistor of 5.1 M$\Omega$ to the CTLD pin in this case.

$V_{CTLD}$: CTLD pin reverse voltage
$V_{CTLD,C}$: CTLD pin reverse voltage during communication

After the DO pin reaches the $V_{SS}$ level due to CTLD pin control, if the voltage difference between the $V_{DD}$ pin and the VM pin decreases to 1.0 V typ. or lower, the power-down function starts to operate. The power-down function is released if either condition mentioned below is satisfied.

(1) $V_{VM} \leq 0.7$ V typ. (Refer to "3. 1 With power-down function")
(2) Changing the PSI pin voltage to be $V_{DS} \rightarrow 0$ V $\rightarrow V_{DS}$ (Refer to "10. PSI pin")

Remark $V_{VM}$: VM pin voltage
$V_{DS}$: Input voltage between the $V_{DD}$ pin and VSS pin ($V1 + V2 + V3 + V4 + V5$)
10. PSI pin

When the PSI pin is activated, the power-saving function starts to operate, and most operations halt. In this case, the CO pin changes to high impedance, DO pin changes to the VSS level, and the PSO pin changes to the VDD level.

<table>
<thead>
<tr>
<th>Table 14 Status Set by PSI Pin</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSI Pin</td>
</tr>
<tr>
<td>VPSI &lt; PSI pin</td>
</tr>
<tr>
<td>PSI pin voltage</td>
</tr>
<tr>
<td>VSS level &lt; PSI pin</td>
</tr>
<tr>
<td>VPSI &lt; PSI pin voltage</td>
</tr>
<tr>
<td>VPSI &lt; C</td>
</tr>
<tr>
<td>PSI pin voltage &lt; VPSI_C</td>
</tr>
<tr>
<td>&quot;H&quot;</td>
</tr>
<tr>
<td>VSS level</td>
</tr>
</tbody>
</table>

Remark The PSI pin is at the VSS level or lower in cascade connection. Connect a resistor of 5.1 MΩ to the PSI pin in this case.

11. Temperature detection

Serially connect an NTC and a low temperature-dependent resistor (RTH) between the VDD pin and the VREG pin, and then connect their middle point to the TH pin. It allows for temperature detection at four different points: high temperature detection during charging, low temperature detection during charging, high temperature detection during discharging, low temperature detection during discharging.

When the temperature rises, according to the NTC temperature characteristics, the resistance (RNTC) decreases, and the ratio between RNTC and RTH changes, and then the TH pin voltage (VRTH) increases.

When the temperature falls, according to the NTC temperature characteristics, the resistance (RNTC) increases, and the ratio between RNTC and RTH changes, and then the TH pin voltage (VRTH) decreases.

The temperature detection during charging and temperature detection during discharging switch by comparing the VM pin voltage (VVM) and charge-discharge discriminating voltage (VCHG).

If the relation between RNTC, RTH, and VVM satisfies the itemized condition in Table 15 in each temperature detection, and each status continues for the temperature detection delay time (tTH) or longer, the CO pin changes to high impedance, and the DO pin changes to the VSS level. This is the temperature protection status.

If the itemized condition in Table 15 is not satisfied in each temperature detection, and each status continues for tTH or longer, the temperature protection status is released.

<table>
<thead>
<tr>
<th>Table 15 Conditions for Each Temperature Detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
</tr>
<tr>
<td>High temperature detection during charging</td>
</tr>
<tr>
<td>Low temperature detection during charging</td>
</tr>
<tr>
<td>High temperature detection during discharging</td>
</tr>
<tr>
<td>Low temperature detection during discharging</td>
</tr>
</tbody>
</table>

Remark
- fTHCH: High temperature detection ratio during charging
- fTHCL: Low temperature detection ratio during charging
- fTHDH: High temperature detection ratio during discharging
- fTHDL: Low temperature detection ratio during discharging
The detection temperature can be set according to the NTC and \( R_{TH} \) characteristics. For example, if \( R_{NTC} \) and \( R_{TH} \) (10 k\( \Omega \)) are connected to the S-8245AAA, each detection temperature is as follows.

**Table 16**

<table>
<thead>
<tr>
<th>Item</th>
<th>Temperature Detection Ratio</th>
<th>( R_{NTC} )</th>
<th>Detection Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature for high temperature detection during charging</td>
<td>( r_{THCH} = 0.670 )</td>
<td>4.9 k( \Omega )</td>
<td>45°C</td>
</tr>
<tr>
<td>Temperature for low temperature detection during charging</td>
<td>( r_{THCL} = 0.270 )</td>
<td>27.0 k( \Omega )</td>
<td>0°C</td>
</tr>
<tr>
<td>Temperature for high temperature detection during discharging</td>
<td>( r_{THDH} = 0.795 )</td>
<td>2.6 k( \Omega )</td>
<td>65°C</td>
</tr>
<tr>
<td>Temperature for low temperature detection during discharging</td>
<td>( r_{THDL} = 0.190 )</td>
<td>42.6 k( \Omega )</td>
<td>–10°C</td>
</tr>
</tbody>
</table>

*1. The calculation method for \( R_{NTC} \) is as follows.

\[
\begin{align*}
  r_{THCL} &= R_{TH} / (R_{NTC} + R_{TH}) \\
  R_{NTC} &= R_{TH} / r_{THCL} - R_{TH} \\
  &= 10 \text{ k}\Omega / 0.270 - 10 \text{ k}\Omega \\
  &= 27.0 \text{ k}\Omega
\end{align*}
\]

When low temperature during charging is detected, \( R_{NTC} = 27.0 \text{ k}\Omega \), so detection temperature = 0°C according to the \( R_{NTC} \) characteristics shown in **Figure 6**.

**Remark**  
Temperature detection is carried out intermittently for 512 ms typ. per cycle, of which 1 ms typ. is the detection operation period.  
The VREG pin voltage is output only during detection operation. During other periods, the VREG pin is at the \( V_{DD} \) level.  
Regarding details of intermittent operation, refer to "4. Temperature detection (High temperature detection during charging)" in "\textit{Timing Charts}".
BATTERY PROTECTION IC FOR 3-SERIAL TO 5-SERIAL CELL PACK
S-8245A/C Series

■ Timing Charts

1. Overcharge detection, overdischarge detection

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

Status*1
(With power-down function)

*1. (1) : Normal status
(2) : Overcharge status
(3) : Overdischarge status
(4) : Power-down status

Figure 7
2. Discharge overcurrent detection

Battery voltage

DO pin voltage

CO pin voltage

VM pin voltage

VINI pin voltage

Load connection

Status

*1. (1) : Normal status
(2) : Discharge overcurrent status

Figure 8
3. Charge overcurrent detection

- **Battery voltage**
  - $V_{CUn}$
  - $V_{CLn}$
  - $V_{DUn}$
  - $V_{DLn}$
  - ($n = 1$ to $5$)

- **DO pin voltage**
  - $V_{SS}$
  - $V_{COH}$

- **CO pin voltage**
  - High-Z
  - High-Z
  - High-Z

- **VM pin voltage**
  - $V_{SS}$
  - $V_{EB}$

- **VINi pin voltage**
  - $V_{SS}$
  - $V_{COV}$

- **Charger connection**

- **Load connection**
  - Charge overcurrent detection delay time ($t_{CIOV}$)
  - Charge overcurrent detection delay time ($t_{CIOV}$)

- **Status**
  - (1) Normal status
  - (2) Charge overcurrent status
  - (3) Overdischarge status
  - (4) Power-down status

*(With power-down function)*

*Figure 9*
4. Temperature detection (High temperature detection during charging)

\[ V_{THCH} = (1 - r_{THCH}) \times V_{REG} \]

TH pin voltage

\[ V_{THCL} = (1 - r_{THCL}) \times V_{REG} \]

DO pin voltage

\[ V_{DD} \]

DO pin voltage

\[ V_{DOH} \]

DO pin voltage

\[ V_{COH} \]

CO pin voltage

\[ V_{SS} \]

CO pin voltage

\[ V_{CHG} \]

CO pin voltage

\[ V_{EB} \]

CO pin voltage

\[ V_{REG} \]

CO pin voltage

\[ V_{VCHG} \]

CO pin voltage

\[ V_{SS} \]

CO pin voltage

\[ V_{EB} \]

CO pin voltage

\[ V_{THCH} = (1 - r_{THCH}) \times V_{REG} \]

Temperature detection delay time \( t_{TH} \)

\( V_{THCL} = (1 - r_{THCL}) \times V_{REG} \)

\( (1) \) Normal status

\( (2) \) Temperature detection sleep time

\( (3) \) Temperature detection awake time

\( (4) \) Temperature protection status

Figure 10
Connection Examples of Battery Protection IC

1. S-8245A Series (10-serial cell with an integrated charge and discharge path)

Remark  Regarding the recommended values for external components, refer to "Table 17 Constants for External Components".
2. S-8245C Series (10-serial cell with separate charge and discharge paths)

Remark  Regarding the recommended values for external components, refer to "Table 17  Constants for External Components".

Figure 12

ABLIC Inc. 27
Table 17 Constants for External Components

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>RVDD1, RVDD2</td>
<td>68</td>
<td>100</td>
<td>100</td>
<td>Ω</td>
</tr>
<tr>
<td>RSEL11, RSEL12, RSEL21, RSEL22</td>
<td>1</td>
<td>1</td>
<td>–</td>
<td>kΩ</td>
</tr>
<tr>
<td>RVIN1, RVIN2</td>
<td>1.0</td>
<td>1.0</td>
<td>5.1</td>
<td>kΩ</td>
</tr>
<tr>
<td>RCTCL, RCTLD, RPSI</td>
<td>1.0</td>
<td>2.0</td>
<td>5.1</td>
<td>kΩ</td>
</tr>
<tr>
<td>RVAM1, RVAM2</td>
<td>1.0</td>
<td>5.1</td>
<td>5.1</td>
<td>kΩ</td>
</tr>
<tr>
<td>RCTLC_c, RCTLD_c, RPSI_c</td>
<td>4.0</td>
<td>5.1</td>
<td>6.0</td>
<td>MΩ</td>
</tr>
<tr>
<td>RCAST, RCIT2, RCICT</td>
<td>1</td>
<td>1</td>
<td>–</td>
<td>kΩ</td>
</tr>
<tr>
<td>RCO</td>
<td>1.0</td>
<td>5.1</td>
<td>–</td>
<td>MΩ</td>
</tr>
<tr>
<td>RDO</td>
<td>1.0</td>
<td>5.1</td>
<td>20.0</td>
<td>kΩ</td>
</tr>
<tr>
<td>REB</td>
<td>–</td>
<td>10</td>
<td>10</td>
<td>MΩ</td>
</tr>
<tr>
<td>NTC1, NTC2</td>
<td>–</td>
<td>10</td>
<td>–</td>
<td>kΩ</td>
</tr>
<tr>
<td>RTH1, RTH2</td>
<td>–</td>
<td>10</td>
<td>–</td>
<td>kΩ</td>
</tr>
<tr>
<td>RSENSE</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>mΩ</td>
</tr>
<tr>
<td>CVDD1, CVDD2</td>
<td>0.68</td>
<td>1.00</td>
<td>10.00</td>
<td>μF</td>
</tr>
<tr>
<td>CVCH1, CVCH2 (n = 1 to 5)</td>
<td>0.068</td>
<td>0.100</td>
<td>1.000</td>
<td>μF</td>
</tr>
<tr>
<td>CCTLC_c, CCTLD_c, CPSI_c</td>
<td>470</td>
<td>470</td>
<td>–</td>
<td>pF</td>
</tr>
<tr>
<td>CCIT1, CCIT2</td>
<td>0.01</td>
<td>0.10</td>
<td>–</td>
<td>μF</td>
</tr>
<tr>
<td>CCD1, CCD2</td>
<td>0.01</td>
<td>0.10</td>
<td>–</td>
<td>μF</td>
</tr>
<tr>
<td>CCIT</td>
<td>0.01</td>
<td>0.10</td>
<td>–</td>
<td>μF</td>
</tr>
<tr>
<td>CCDIT</td>
<td>0.01</td>
<td>0.10</td>
<td>–</td>
<td>μF</td>
</tr>
<tr>
<td>CTTH1, CTTH2</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>μF</td>
</tr>
<tr>
<td>D1</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

*1. \( R_{VDD1} \times C_{VDD1} = R_{VDD2} \times C_{VDD2} = 100 \, \mu F \times \Omega \) is recommended.

Caution 1. The above constants may be changed without notice.

2. Sufficient evaluation of transient power supply fluctuation and overcurrent protection function with the actual application is needed to determine the proper constants when setting the filter constants between the VDD pin and VSS pin. Contact our sales office if setting the constants between the VDD pin and VSS pin to anything other than the recommended values.

3. It has not been confirmed whether the operation is normal or not in circuits other than the connection examples. In addition, the connection examples and the constants do not guarantee proper operation. Perform thorough evaluation using the actual application to set the constants.
Precautions

- The application conditions for the input voltage, output voltage, and load current should not exceed the power dissipation.

- Batteries can be connected in any order; however, there may be cases when discharging cannot be performed after a battery is connected. In this case, the S-8245A/C Series returns to the normal status when any of the following conditions is satisfied.

  1. Connecting a charger
  2. Shorting between the VM pin and the VSS pin
  3. Changing the PSI pin voltage to be $V_{DS} \rightarrow 0 \rightarrow V_{DS}$

  **Remark**  $V_{DS}$: Input voltage between the VDD pin and the VSS pin ($V_1 + V_2 + V_3 + V_4 + V_5$)

- If an overcharged battery and an overdischarged battery intermix, the S-8245A/C Series will change to the overcharge and overdischarge statuses. Therefore, in this case, both charging and discharging are impossible.

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

- ABLIC Inc. claims no responsibility for any disputes arising out of or in connection with any infringement by products including this IC of patents owned by a third party.
Characteristics (Typical Data)

1. Current consumption

1.1 \( I_{OPE} \) vs. \( V_{DS} \)

\[ Ta = +25^\circ C \]

1.2 \( I_{OPE} \) vs. \( Ta \)

\[ V_{DS} = 17.5 \text{ V} \]

1.3 \( I_{PDN} \) vs. \( V_{DS} \)

\[ Ta = +25^\circ C \]

1.4 \( I_{PDN} \) vs. \( Ta \)

\[ V_{DS} = 7.5 \text{ V} \]

1.5 \( I_{PSV} \) vs. \( V_{DS} \)

\[ Ta = +25^\circ C \]

1.6 \( I_{PSV} \) vs. \( Ta \)

\[ V_{DS} = 17.5 \text{ V} \]
2. Detection voltage, release voltage

2.1 \( V_{\text{CU}} \) vs. \( T_a \)

2.2 \( V_{\text{CL}} \) vs. \( T_a \)

2.3 \( V_{\text{DL}} \) vs. \( T_a \)

2.4 \( V_{\text{DU}} \) vs. \( T_a \)

2.5 \( V_{\text{DIOV1}} \) vs. \( T_a \)

2.6 \( V_{\text{DIOV2}} \) vs. \( T_a \)

2.7 \( V_{\text{SHORT}} \) vs. \( T_a \)

2.8 \( V_{\text{CIOV}} \) vs. \( T_a \)
3. Delay time function

3.1 \( R_{\text{CCT}} \) vs. \( T_a \)

\[
\begin{array}{cccccccc}
\text{Ta [°C]} & -40 & -25 & 0 & 25 & 50 & 75 & 85 \\
\hline
R_{\text{CCT}} [M\Omega] & 16 & 12 & 8 & 4 & 2 & 1 & 0
\end{array}
\]

\( V_{DS} = 19 \text{ V} \)

3.2 \( V_{\text{CCT}} \) vs. \( T_a \)

\[
\begin{array}{cccccccc}
\text{Ta [°C]} & -40 & -25 & 0 & 25 & 50 & 75 & 85 \\
\hline
V_{\text{CCT}} [V] & 14.0 & 13.5 & 13.0 & 12.5 & 12.0 & 11.5 & 11.0
\end{array}
\]

\( V_{DS} = 19 \text{ V} \)

3.3 \( R_{\text{CDT}} \) vs. \( T_a \)

\[
\begin{array}{cccccccc}
\text{Ta [°C]} & -40 & -25 & 0 & 25 & 50 & 75 & 85 \\
\hline
R_{\text{CDT}} [k\Omega] & 1500 & 1200 & 900 & 600 & 300 & 200 & 100 & 50
\end{array}
\]

\( V_{DS} = 15.5 \text{ V} \)

3.4 \( V_{\text{CDT}} \) vs. \( T_a \)

\[
\begin{array}{cccccccc}
\text{Ta [°C]} & -40 & -25 & 0 & 25 & 50 & 75 & 85 \\
\hline
V_{\text{CDT}} [V] & 12 & 11 & 10 & 9 & 8 & 7 & 6 & 5 & 4
\end{array}
\]

\( V_{DS} = 15.5 \text{ V} \)

3.5 \( R_{\text{CIT}} \) vs. \( T_a \)

\[
\begin{array}{cccccccc}
\text{Ta [°C]} & -40 & -25 & 0 & 25 & 50 & 75 & 85 \\
\hline
R_{\text{CIT}} [k\Omega] & 1500 & 1200 & 900 & 600 & 300 & 200 & 100 & 50
\end{array}
\]

\( V_{DS} = 17.5 \text{ V} \)

3.6 \( V_{\text{CIT}} \) vs. \( T_a \)

\[
\begin{array}{cccccccc}
\text{Ta [°C]} & -40 & -25 & 0 & 25 & 50 & 75 & 85 \\
\hline
V_{\text{CIT}} [V] & 14 & 13 & 12 & 11 & 10 & 9 & 8 & 7 & 6 & 5 & 4
\end{array}
\]

\( V_{DS} = 17.5 \text{ V} \)

3.7 \( R_{\text{CIT2}} \) vs. \( T_a \)

\[
\begin{array}{cccccccc}
\text{Ta [°C]} & -40 & -25 & 0 & 25 & 50 & 75 & 85 \\
\hline
R_{\text{CIT2}} [k\Omega] & 300 & 200 & 100 & 50 & 25 & 10 & 5 & 2.5 & 1.25 & 0.5
\end{array}
\]

\( V_{DS} = 17.5 \text{ V} \)

3.8 \( V_{\text{CIT2}} \) vs. \( T_a \)

\[
\begin{array}{cccccccc}
\text{Ta [°C]} & -40 & -25 & 0 & 25 & 50 & 75 & 85 \\
\hline
V_{\text{CIT2}} [V] & 14 & 13 & 12 & 11 & 10 & 9 & 8 & 7 & 6 & 5 & 4
\end{array}
\]

\( V_{DS} = 17.5 \text{ V} \)
3.9 $R_{CICT}$ vs. $T_a$

![Graph showing $R_{CICT}$ vs. $T_a$]

3.10 $V_{CICT}$ vs. $T_a$

![Graph showing $V_{CICT}$ vs. $T_a$]

3.11 $t_{SHORT}$ vs. $T_a$

![Graph showing $t_{SHORT}$ vs. $T_a$]
4. Output pin

4.1 $I_{COH}$ vs. $V_{DS}$

4.2 $I_{COL}$ vs. $V_{DS}$

4.3 $I_{DOH}$ vs. $V_{DS}$

4.4 $I_{DOL}$ vs. $V_{DS}$

4.5 $I_{PSOH}$ vs. $V_{DS}$

4.6 $I_{PSOL}$ vs. $V_{DS}$

4.7 $V_{COH}$ vs. $T_a$

4.8 $V_{DOH}$ vs. $T_a$
5. Temperature detection function

5.1 $r_{THCH}$ vs. $T_a$

5.2 $r_{THCL}$ vs. $T_a$

5.3 $r_{THDH}$ vs. $T_a$

5.4 $r_{THDL}$ vs. $T_a$

5.5 $V_{REG}$ vs. $T_a$

5.6 $V_{CHG}$ vs. $T_a$

5.7 $t_{TH}$ vs. $T_a$
### Power Dissipation

#### 24-Pin SSOP

![Power Dissipation Graph]

<table>
<thead>
<tr>
<th>Board</th>
<th>Power Dissipation (PD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.43 W</td>
</tr>
<tr>
<td>B</td>
<td>1.67 W</td>
</tr>
<tr>
<td>C</td>
<td>–</td>
</tr>
<tr>
<td>D</td>
<td>–</td>
</tr>
<tr>
<td>E</td>
<td>–</td>
</tr>
</tbody>
</table>
## 24-Pin SSOP Test Board

### (1) Board A

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size [mm]</td>
<td>114.3 x 76.2 x 1.6</td>
</tr>
<tr>
<td>Material</td>
<td>FR-4</td>
</tr>
<tr>
<td>Number of copper foil layer</td>
<td>2</td>
</tr>
<tr>
<td>Copper foil layer [mm]</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Land pattern and wiring for testing: t0.070</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>74.2 x 74.2 x t0.070</td>
</tr>
<tr>
<td>Thermal via</td>
<td>-</td>
</tr>
</tbody>
</table>

### (2) Board B

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size [mm]</td>
<td>114.3 x 76.2 x 1.6</td>
</tr>
<tr>
<td>Material</td>
<td>FR-4</td>
</tr>
<tr>
<td>Number of copper foil layer</td>
<td>4</td>
</tr>
<tr>
<td>Copper foil layer [mm]</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Land pattern and wiring for testing: t0.070</td>
</tr>
<tr>
<td>2</td>
<td>74.2 x 74.2 x t0.035</td>
</tr>
<tr>
<td>3</td>
<td>74.2 x 74.2 x t0.035</td>
</tr>
<tr>
<td>4</td>
<td>74.2 x 74.2 x t0.070</td>
</tr>
<tr>
<td>Thermal via</td>
<td>-</td>
</tr>
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No. SSOP24-A-Board-SD-1.0

ABLIC Inc.
No. FS024-B-P-SD-1.0

<table>
<thead>
<tr>
<th>TITLE</th>
<th>SSOP24-B-PKG Dimensions</th>
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<tbody>
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<td>No.</td>
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<td>ANGLE</td>
<td></td>
</tr>
<tr>
<td>UNIT</td>
<td>mm</td>
</tr>
</tbody>
</table>

ABLIC Inc.
### No. FS024-B-C-SD-1.0

<table>
<thead>
<tr>
<th>TITLE</th>
<th>SSOP24-B-Carrier Tape</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>FS024-B-C-SD-1.0</td>
</tr>
<tr>
<td>ANGLE</td>
<td></td>
</tr>
<tr>
<td>UNIT</td>
<td>mm</td>
</tr>
</tbody>
</table>

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**Dimensions:**
- **Ø1.5** $+0.1 -0$
- **2.0±0.1**
- **4.0±0.1**
- **1.75±0.1**
- **15±0.05**
- **8.4±0.1**
- **7.5±0.1**
- **16.0±0.1**
- **0.3±0.05**
- **8.15±0.1**
- **12.0±0.1**
- **Feed direction**
Enlarged drawing in the central part

<table>
<thead>
<tr>
<th>TITLE</th>
<th>SSOP24-B-Reel</th>
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<tbody>
<tr>
<td>No.</td>
<td>FS024-B-R-SD-1.0</td>
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<tr>
<td>ANGLE</td>
<td>QTY.</td>
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