

**BATTERY PROTECTION IC FOR 2-SERIAL / 3-SERIAL CELL PACK  
(SECONDARY PROTECTION)**
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Rev.1.3\_00

The S-8223A/B/C/D Series is used for secondary protection of lithium-ion rechargeable batteries, and incorporates high-accuracy voltage detection circuits and delay circuits.

Short-circuits between cells accommodate series connection of two cells or three cells.

The S-8223B/D Series limits its CO pin output voltage to 11.5 V max., so a FET with the gate withstand voltage of 12 V can be used.

## ■ Features

- High-accuracy voltage detection circuit for each cell
 

|  |   |
|--|---|
| Overcharge detection voltage n (n = 1 to 3)    |   |
| 3.600 V to 4.700 V (50 mV step)                | Accuracy $\pm 20$ mV ( $T_a = +25^\circ\text{C}$ )                        |
|  | Accuracy $\pm 25$ mV ( $T_a = -10^\circ\text{C}$ to $+60^\circ\text{C}$ ) |
| Overcharge hysteresis voltage n (n = 1 to 3)*1 |   |
| 0.0 mV to $-550$ mV (50 mV step)               |   |
| $-300$ mV to $-550$ mV                         | Accuracy $\pm 20\%$   |
| $-100$ mV to $-250$ mV                         | Accuracy $\pm 50$ mV  |
| $-50$ mV                                       | Accuracy $\pm 25$ mV  |
| 0.0 mV   | Accuracy $-25$ mV to $+20$ mV   |
- Delay times for overcharge detection are generated only by an internal circuit (external capacitors are unnecessary)
 

|  |                         |
|--|-------------------------|
| Overcharge detection delay time is selectable: | 1 s, 2 s, 4 s, 6 s, 8 s |
| Overcharge release delay time is selectable:   | 2 ms, 64 ms             |
- Built-in timer reset delay circuit
- Output form is selectable (S-8223A/C Series): CMOS output, Nch open-drain output
- Output logic is selectable (S-8223A/C Series): Active "H", active "L"
- CO pin output voltage is limited to 11.5 V max. (S-8223B/D Series)\*2
- High-withstand voltage: Absolute maximum rating 28 V
- Wide operation voltage range: 3.6 V to 28 V
- Wide operation temperature range:  $T_a = -40^\circ\text{C}$  to  $+85^\circ\text{C}$
- Low current consumption
 

|  |   |
|--|---|
| During operation ( $V_{CU} - 1.0$ V for each cell):          | 0.25 $\mu\text{A}$ typ., 0.5 $\mu\text{A}$ max. ( $T_a = +25^\circ\text{C}$ ) |
| During overdischarge ( $V_{CU} \times 0.5$ V for each cell): | 0.3 $\mu\text{A}$ max. ( $T_a = +25^\circ\text{C}$ )                          |
- Lead-free (Sn 100%), halogen-free

\*1. Select the overcharge hysteresis voltage calculated as the following formula.

(Overcharge detection voltage n) + (Overcharge hysteresis voltage n)  $\geq 3.4$  V

\*2. Only output logic active "H" is available.

## ■ Application

- Lithium-ion rechargeable battery packs (for secondary protection)

## ■ Package

- SNT-6A

## ■ Block Diagrams

### 1. S-8223A/C Series

#### 1.1 CMOS output product

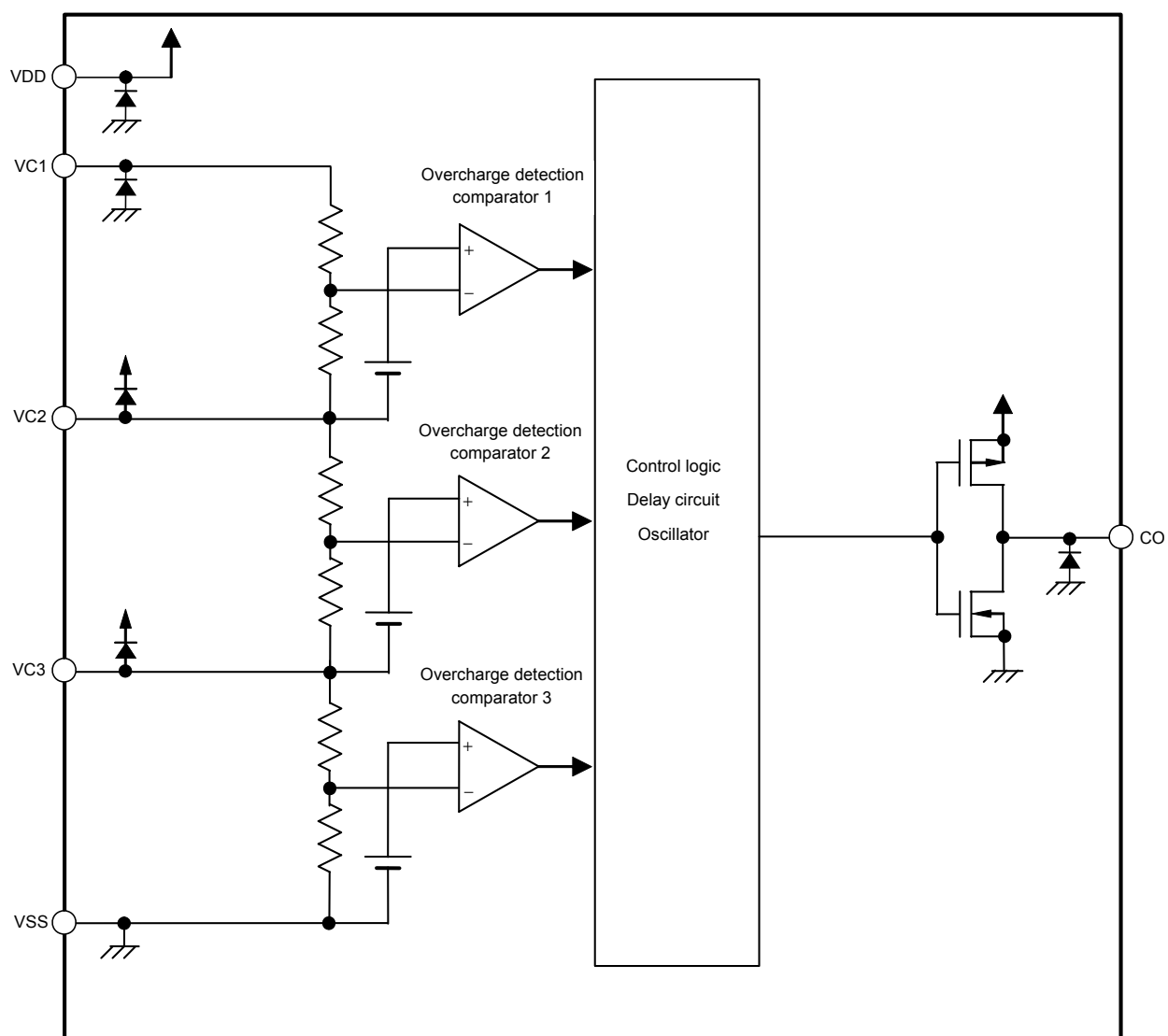


Figure 1

## 1.2 Nch open-drain output product

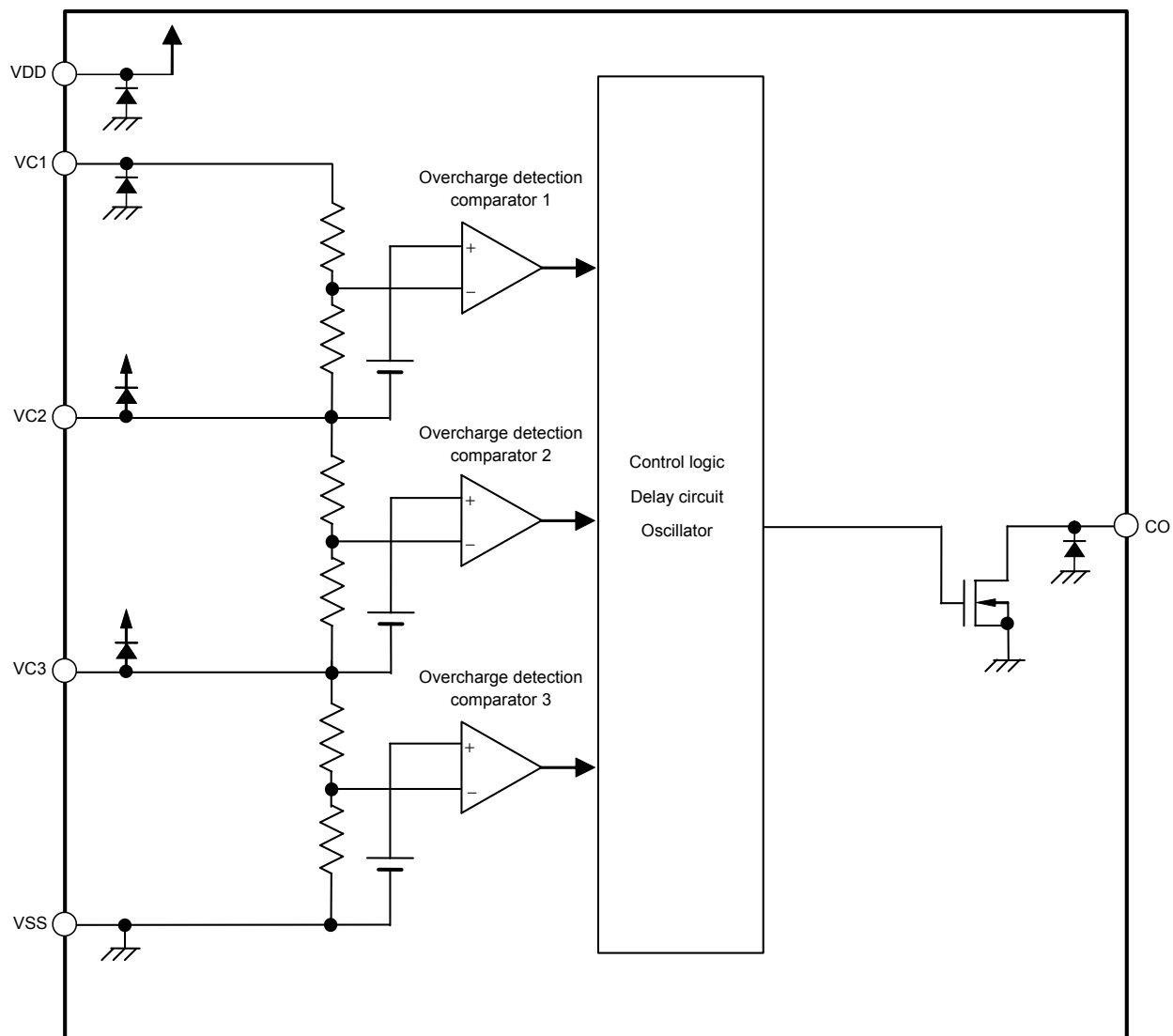


Figure 2

## 2. S-8223B/D Series

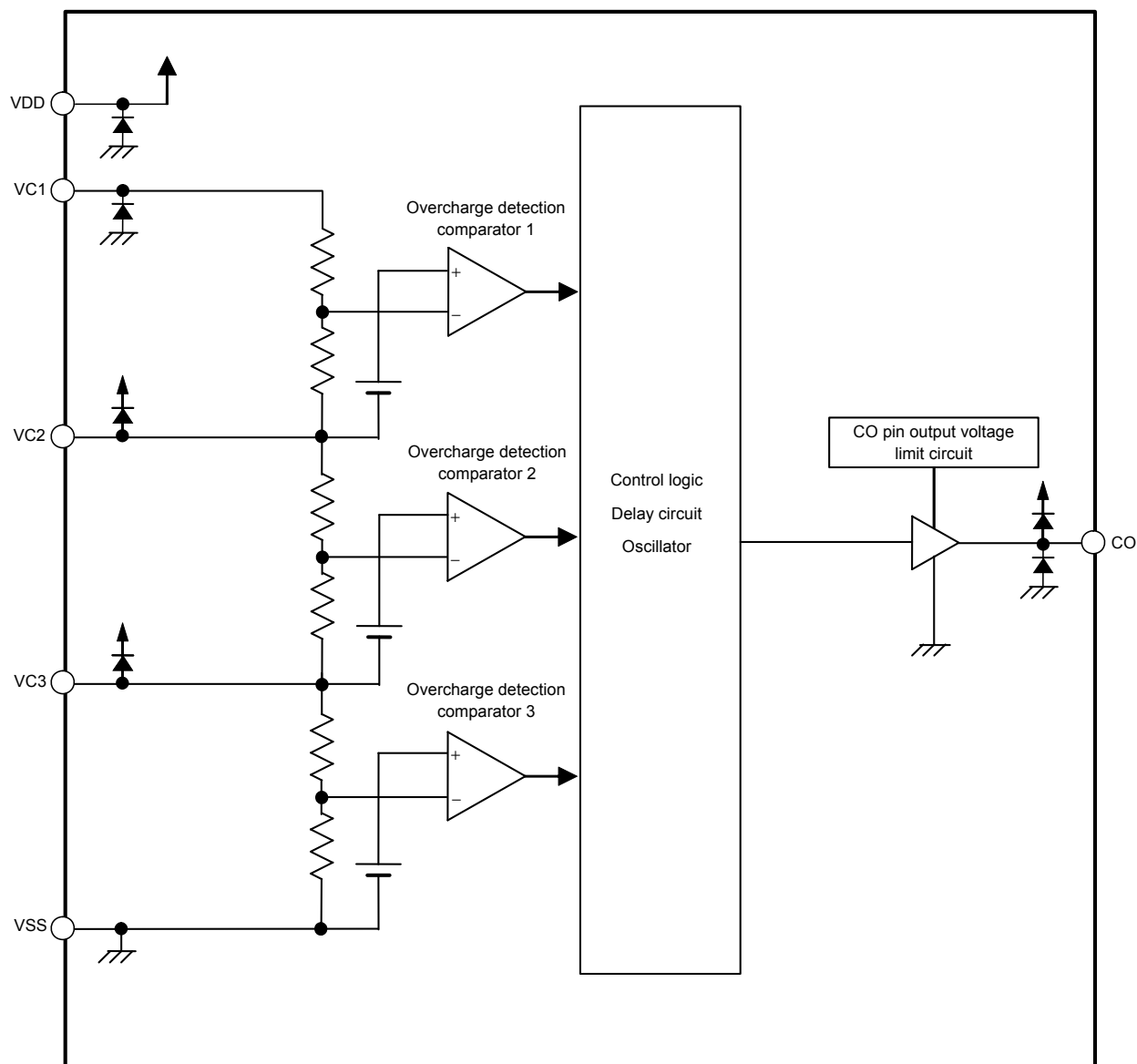
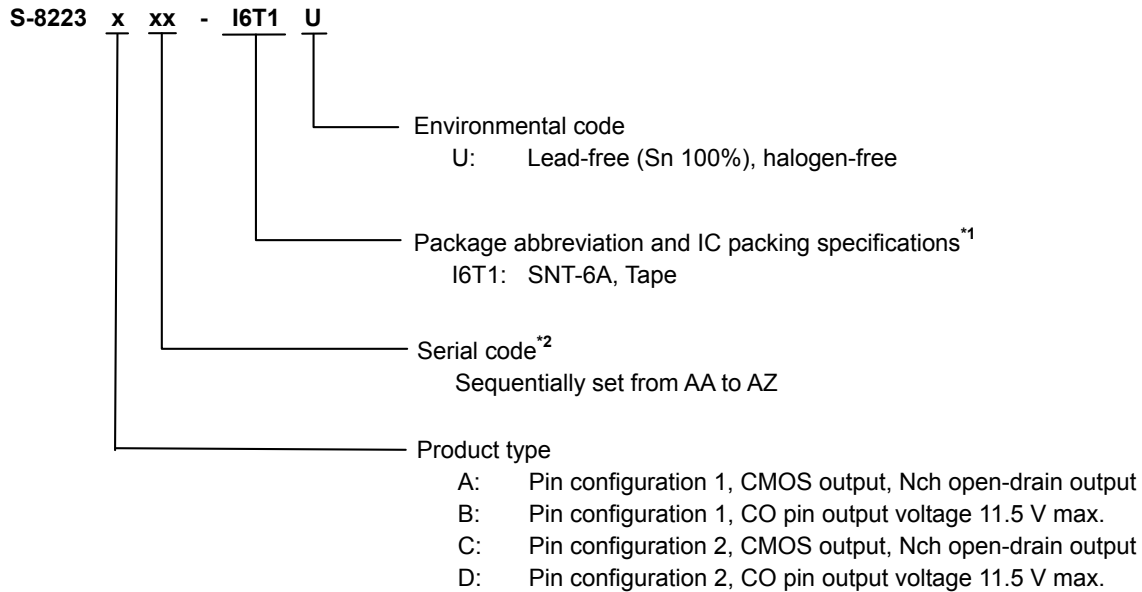


Figure 3

## ■ Product Name Structure

### 1. Product name



\*1. Refer to the tape drawing.

\*2. Refer to "3. Product name list".

### 2. Package

Table 1 Package Drawing Codes

| Package Name | Dimension    | Tape         | Reel         | Land         |
|--------------|--------------|--------------|--------------|--------------|
| SNT-6A       | PG006-A-P-SD | PG006-A-C-SD | PG006-A-R-SD | PG006-A-L-SD |

### 3. Product name list

#### 3.1 S-8223A Series

Table 2

| Product Name    | Overcharge Detection Voltage [V <sub>CU</sub> ] | Overcharge Hysteresis Voltage [V <sub>HC</sub> ] | Overcharge Detection Delay Time <sup>*1</sup> [t <sub>CU</sub> ] | Overcharge Release Delay Time <sup>*2</sup> [t <sub>CL</sub> ] | Output Form <sup>*3</sup> | Output Logic <sup>*4</sup> |
|-----------------|---|--|--|--|---------------------------|----------------------------|
| S-8223AAA-I6T1U | 4.450 V   | -400 mV  | 6 s  | 64 ms  | CMOS output               | Active "H"                 |
| S-8223AAB-I6T1U | 4.500 V   | -400 mV  | 6 s  | 64 ms  | CMOS output               | Active "H"                 |
| S-8223AAC-I6T1U | 4.350 V   | -400 mV  | 6 s  | 64 ms  | CMOS output               | Active "H"                 |
| S-8223AAD-I6T1U | 4.400 V   | -400 mV  | 6 s  | 64 ms  | CMOS output               | Active "H"                 |
| S-8223AAE-I6T1U | 4.550 V   | -400 mV  | 6 s  | 64 ms  | CMOS output               | Active "H"                 |
| S-8223AAF-I6T1U | 4.500 V   | -400 mV  | 6 s  | 2 ms   | CMOS output               | Active "H"                 |
| S-8223AAG-I6T1U | 4.550 V   | -400 mV  | 6 s  | 2 ms   | CMOS output               | Active "H"                 |
| S-8223AAH-I6T1U | 4.350 V   | -400 mV  | 4 s  | 64 ms  | CMOS output               | Active "H"                 |
| S-8223AAI-I6T1U | 4.500 V   | -400 mV  | 4 s  | 64 ms  | CMOS output               | Active "H"                 |
| S-8223AAJ-I6T1U | 4.550 V   | -400 mV  | 4 s  | 64 ms  | CMOS output               | Active "H"                 |

\*1. Overcharge detection delay time 1 s / 2 s / 4 s / 6 s / 8 s is selectable.

\*2. Overcharge release delay time 2 ms / 64 ms is selectable.

\*3. Output form CMOS output / Nch open-drain output is selectable.

\*4. Output logic active "H" / active "L" is selectable.

**Remark** Please contact our sales office for the products with detection voltage value other than those specified above.

### 3.2 S-8223B Series

**Table 3**

| Product Name    | Overcharge Detection Voltage [V <sub>CU</sub> ] | Overcharge Hysteresis Voltage [V <sub>HC</sub> ] | Overcharge Detection Delay Time <sup>*1</sup> [t <sub>CU</sub> ] | Overcharge Release Delay Time <sup>*2</sup> [t <sub>CL</sub> ] | Output Logic <sup>*3</sup> |
|-----------------|---|--|--|--|----------------------------|
| S-8223BAA-I6T1U | 4.500 V   | −300 mV  | 4 s  | 2 ms   | Active "H"                 |

\*1. Overcharge detection delay time 1 s / 2 s / 4 s / 6 s / 8 s is selectable.

\*2. Overcharge release delay time 2 ms / 64 ms is selectable.

\*3. Only output logic active "H" is available.

**Remark** Please contact our sales office for the products with detection voltage value other than those specified above.

### 3.3 S-8223C Series

**Table 4**

| Product Name    | Overcharge Detection Voltage [V <sub>CU</sub> ] | Overcharge Hysteresis Voltage [V <sub>HC</sub> ] | Overcharge Detection Delay Time <sup>*1</sup> [t <sub>CU</sub> ] | Overcharge Release Delay Time <sup>*2</sup> [t <sub>CL</sub> ] | Output Form <sup>*3</sup> | Output Logic <sup>*4</sup> |
|-----------------|---|--|--|--|---------------------------|----------------------------|
| S-8223CAA-I6T1U | 4.400 V   | −400 mV  | 4 s  | 2 ms   | CMOS output               | Active "H"                 |
| S-8223CAB-I6T1U | 4.450 V   | −400 mV  | 4 s  | 2 ms   | CMOS output               | Active "H"                 |
| S-8223CAC-I6T1U | 4.500 V   | −400 mV  | 4 s  | 2 ms   | CMOS output               | Active "H"                 |
| S-8223CAD-I6T1U | 4.350 V   | −400 mV  | 4 s  | 2 ms   | CMOS output               | Active "H"                 |
| S-8223CAE-I6T1U | 4.250 V   | −50 mV   | 2 s  | 2 ms   | Nch open-drain output     | Active "H"                 |
| S-8223CAF-I6T1U | 4.150 V   | −50 mV   | 2 s  | 2 ms   | Nch open-drain output     | Active "H"                 |
| S-8223CAG-I6T1U | 4.350 V   | −400 mV  | 2 s  | 2 ms   | CMOS output               | Active "H"                 |
| S-8223CAH-I6T1U | 4.450 V   | −400 mV  | 2 s  | 2 ms   | CMOS output               | Active "H"                 |
| S-8223CAI-I6T1U | 4.500 V   | −400 mV  | 2 s  | 2 ms   | CMOS output               | Active "H"                 |
| S-8223CAJ-I6T1U | 4.300 V   | −400 mV  | 4 s  | 2 ms   | CMOS output               | Active "H"                 |
| S-8223CAK-I6T1U | 4.200 V   | −400 mV  | 2 s  | 2 ms   | Nch open-drain output     | Active "H"                 |

\*1. Overcharge detection delay time 1 s / 2 s / 4 s / 6 s / 8 s is selectable.

\*2. Overcharge release delay time 2 ms / 64 ms is selectable.

\*3. Output form CMOS output / Nch open-drain output is selectable.

\*4. Output logic active "H" / active "L" is selectable.

**Remark** Please contact our sales office for the products with detection voltage value other than those specified above.

## ■ Pin Configuration

### 1. SNT-6A

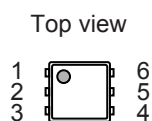


Figure 4

Table 5 S-8223A/B Series (Pin Configuration 1)

| Pin No. | Symbol | Description  |
|---------|--------|--|
| 1       | VC1    | Positive voltage connection pin of battery 1   |
| 2       | VC2    | Negative voltage connection pin of battery 1<br>Positive voltage connection pin of battery 2 |
| 3       | VSS    | Negative power supply input pin<br>Negative voltage connection pin of battery 3              |
| 4       | VC3    | Negative voltage connection pin of battery 2<br>Positive voltage connection pin of battery 3 |
| 5       | VDD    | Positive power supply input pin  |
| 6       | CO     | FET gate connection pin for charge control   |

Table 6 S-8223C/D Series (Pin Configuration 2)

| Pin No. | Symbol | Description  |
|---------|--------|--|
| 1       | CO     | FET gate connection pin for charge control   |
| 2       | VDD    | Positive power supply input pin  |
| 3       | VC1    | Positive voltage connection pin of battery 1   |
| 4       | VC2    | Negative voltage connection pin of battery 1<br>Positive voltage connection pin of battery 2 |
| 5       | VC3    | Negative voltage connection pin of battery 2<br>Positive voltage connection pin of battery 3 |
| 6       | VSS    | Negative power supply input pin<br>Negative voltage connection pin of battery 3              |

## ■ Absolute Maximum Ratings

Table 7

(Ta = +25°C unless otherwise specified)

| Item                                      |                  |                       | Symbol           | Applied Pin | Absolute Maximum Rating                        | Unit |
|---|------------------|-----------------------|------------------|-------------|--|------|
| Input voltage between VDD pin and VSS pin |                  |                       | V <sub>DS</sub>  | VDD         | V <sub>SS</sub> – 0.3 to V <sub>SS</sub> + 28  | V    |
| Input pin voltage                         |                  |                       | V <sub>IN</sub>  | VC1         | V <sub>SS</sub> – 0.3 to V <sub>SS</sub> + 28  | V    |
|   |                  |                       |                  | VC2, VC3    | V <sub>DD</sub> – 28 to V <sub>DD</sub> + 0.3  | V    |
| CO pin output voltage                     | S-8223A/C Series | CMOS output           | V <sub>CO</sub>  | CO          | V <sub>SS</sub> – 0.3 to V <sub>DD</sub> + 0.3 | V    |
|   |                  | Nch open-drain output |                  |             | V <sub>SS</sub> – 0.3 to V <sub>SS</sub> + 28  | V    |
|   | S-8223B/D Series |                       |                  |             | V <sub>SS</sub> – 0.3 to V <sub>DD</sub> + 0.3 | V    |
| Operation ambient temperature             |                  |                       | T <sub>opr</sub> | –           | –40 to +85                                     | °C   |
| Storage temperature                       |                  |                       | T <sub>sta</sub> | –           | –40 to +125                                    | °C   |

**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 8

| Table 6                                  |               |           |         |      |      |      |      |
|--|---------------|-----------|---------|------|------|------|------|
| Item                                     | Symbol        | Condition |         | Min. | Typ. | Max. | Unit |
| Junction-to-ambient thermal resistance*1 | $\theta_{JA}$ | SNT-6A    | Board A | –    | 224  | –    | °C/W |
|  |               |           | Board B | –    | 176  | –    | °C/W |
|  |               |           | Board C | –    | –    | –    | °C/W |
|  |               |           | Board D | –    | –    | –    | °C/W |
|  |               |           | Board E | –    | –    | –    | °C/W |

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

**Remark** Refer to "■ Power Dissipation" and "Test Board" for details.



## ■ Electrical Characteristics

Table 9

(Ta = +25°C unless otherwise specified)

| Item   | Symbol                      | Condition  | Min.                       | Typ.            | Max.                       | Unit | Test Circuit |
|--|-----------------------------|--|----------------------------|-----------------|----------------------------|------|--------------|
| Detection Voltage                                |                             |  |                            |                 |                            |      |              |
| Overcharge detection voltage n<br>(n = 1, 2, 3)  | V <sub>CU<sub>n</sub></sub> | Ta = +25°C   | V <sub>CU</sub><br>− 0.020 | V <sub>CU</sub> | V <sub>CU</sub><br>+ 0.020 | V    | 1            |
|  |                             | Ta = −10°C to +60°C*1  | V <sub>CU</sub><br>− 0.025 | V <sub>CU</sub> | V <sub>CU</sub><br>+ 0.025 | V    | 1            |
| Overcharge hysteresis voltage n<br>(n = 1, 2, 3) | V <sub>HC<sub>n</sub></sub> | −550 mV ≤ V <sub>HC</sub> ≤ −300 mV                            | V <sub>HC</sub> × 1.2      | V <sub>HC</sub> | V <sub>HC</sub> × 0.8      | V    | 1            |
|  |                             | −250 mV ≤ V <sub>HC</sub> ≤ −100 mV                            | V <sub>HC</sub><br>− 0.050 | V <sub>HC</sub> | V <sub>HC</sub><br>+ 0.050 | V    | 1            |
|  |                             | V <sub>HC</sub> = −50 mV                                       | V <sub>HC</sub><br>− 0.025 | V <sub>HC</sub> | V <sub>HC</sub><br>+ 0.025 | V    | 1            |
|  |                             | V <sub>HC</sub> = 0.0 mV                                       | V <sub>HC</sub><br>− 0.025 | V <sub>HC</sub> | V <sub>HC</sub><br>+ 0.020 | V    | 1            |
| Input Voltage                                    |                             |  |                            |                 |                            |      |              |
| Operation voltage between<br>VDD pin and VSS pin | V <sub>DSOP</sub>           | —  | 3.6                        | —               | 28                         | V    | —            |
| Output Voltage                                   |                             |  |                            |                 |                            |      |              |
| CO pin output voltage "H"                        | V <sub>COH</sub>            | S-8223B/D Series   | 5.0                        | 8.0             | 11.5                       | V    | 1            |
| Input Current                                    |                             |  |                            |                 |                            |      |              |
| Current consumption<br>during operation          | I <sub>OPE</sub>            | V1 = V2 = V3 = V <sub>CU</sub> − 1.0 V                         | —                          | 0.25            | 0.5                        | μA   | 2            |
| Current consumption<br>during overdischarge      | I <sub>OPED</sub>           | V1 = V2 = V3 = V <sub>CU</sub> × 0.5 V                         | —                          | —               | 0.3                        | μA   | 2            |
| VC1 pin input current                            | I <sub>VC1</sub>            | V1 = V2 = V3 = V <sub>CU</sub> − 1.0 V                         | —                          | —               | 0.3                        | μA   | 3            |
| VCn pin input current (n = 2, 3)                 | I <sub>VCn</sub>            | V1 = V2 = V3 = V <sub>CU</sub> − 1.0 V                         | −0.3                       | 0               | 0.3                        | μA   | 3            |
| Output Current                                   |                             |  |                            |                 |                            |      |              |
| CO pin source current                            | I <sub>COH</sub>            | S-8223A/C Series<br>(CMOS output product),<br>S-8223B/D Series | —                          | —               | −20                        | μA   | 4            |
| CO pin sink current                              | I <sub>COL</sub>            | —  | 20                         | —               | —                          | μA   | 4            |
| CO pin leakage current                           | I <sub>COLL</sub>           | S-8223A/C Series<br>(Nch open-drain output product)            | —                          | —               | 0.1                        | μA   | 4            |
| Delay Time                                       |                             |  |                            |                 |                            |      |              |
| Overcharge detection delay time                  | t <sub>CU</sub>             | —  | t <sub>CU</sub> × 0.8      | t <sub>CU</sub> | t <sub>CU</sub> × 1.2      | s    | 1            |
| Overcharge release delay time                    | t <sub>CL</sub>             | t <sub>CL</sub> = 2 ms   | 1.6                        | 2.0             | 3.0                        | ms   | 1            |
|  |                             | t <sub>CL</sub> = 64 ms  | 51.2                       | 64              | 76.8                       | ms   | 1            |
| Overcharge timer reset delay time                | t <sub>TR</sub>             | —  | 6                          | 12              | 20                         | ms   | 1            |
| Transition time to test mode                     | t <sub>TST</sub>            | —  | —                          | —               | 10                         | ms   | 1            |

\*1. Since products are not screened at high and low temperature, the specification for this temperature range is guaranteed by design, not tested in production.

## ■ Test Circuits

### 1. Overcharge detection voltage, overcharge hysteresis voltage (Test circuit 1)

Set SW1 to OFF in CMOS output product of the S-8223A/C Series and in the S-8223B/D Series, and set SW1 to ON in Nch open-drain output product of the S-8223A/C Series.

#### 1. 1 Overcharge detection voltage $n$ ( $V_{CU_n}$ )

Set  $V_0 = 0\text{ V}$ ,  $V_1 = V_2 = V_3 = V_{CU} - 0.05\text{ V}$  in test circuit 1. The overcharge detection voltage 1 ( $V_{CU1}$ ) is the  $V_1$  voltage when the CO pin output inverts after the  $V_1$  voltage has been gradually increased.

Overcharge detection voltage ( $V_{CU_n}$ ) ( $n = 2$  to  $3$ ) can be determined in the same way as when  $n = 1$ .

#### 1. 2 Overcharge hysteresis voltage $n$ ( $V_{HC_n}$ )

Set  $V_0 = 0\text{ V}$ ,  $V_1 = V_{CU} + 0.05\text{ V}$ ,  $V_2 = V_3 = 2.5\text{ V}$ . The overcharge hysteresis voltage 1 ( $V_{HC1}$ ) is the difference between  $V_1$  voltage and  $V_{CU1}$  when the CO pin output inverts again after the  $V_1$  voltage has been gradually decreased.

Overcharge hysteresis voltage ( $V_{HC_n}$ ) ( $n = 2$  to  $3$ ) can be determined in the same way as when  $n = 1$ .

### 2. Output voltage (S-8223B/D Series) (Test circuit 1)

Set SW1 to OFF in the S-8223B/D Series.

#### 2. 1 CO pin output voltage "H"

The CO pin output voltage "H" ( $V_{COH}$ ) is the voltage between the CO pin and the VSS pin when  $V_0 = 0\text{ V}$ ,  $V_1 = V_2 = V_3 = 5.2\text{ V}$ .

### 3. Output current (Test circuit 4)

#### 3. 1 CMOS output product in S-8223A/C Series

Set SW4 and SW5 to OFF.

##### 3. 1. 1 Active "H"

##### (1) CO pin source current ( $I_{COH}$ )

Set SW4 to ON after setting  $V_1 = 5.2\text{ V}$ ,  $V_2 = 2.8\text{ V}$ ,  $V_3 = 2.5\text{ V}$ ,  $V_4 = 0.5\text{ V}$ .  $I_1$  is the CO pin source current ( $I_{COH}$ ) at that time.

##### (2) CO pin sink current ( $I_{COL}$ )

Set SW5 to ON after setting  $V_1 = V_2 = V_3 = 3.5\text{ V}$ ,  $V_5 = 0.5\text{ V}$ .  $I_2$  is the CO pin sink current ( $I_{COL}$ ) at that time.

##### 3. 1. 2 Active "L"

##### (1) CO pin source current ( $I_{COH}$ )

Set SW4 to ON after setting  $V_1 = V_2 = V_3 = 3.5\text{ V}$ ,  $V_4 = 0.5\text{ V}$ .  $I_1$  is the CO pin source current ( $I_{COH}$ ) at that time.

##### (2) CO pin sink current ( $I_{COL}$ )

Set SW5 to ON after setting  $V_1 = 5.2\text{ V}$ ,  $V_2 = 2.8\text{ V}$ ,  $V_3 = 2.5\text{ V}$ ,  $V_4 = 0.5\text{ V}$ .  $I_2$  is the CO pin sink current ( $I_{COL}$ ) at that time.

### 3.2 Nch open-drain output product in S-8223A/C Series

Set SW4 and SW5 to OFF.

#### 3.2.1 Active "H"

##### (1) CO pin leakage current ( $I_{COLL}$ )

Set SW5 to ON after setting  $V1 = 9.4\text{ V}$ ,  $V2 = V3 = 9.3\text{ V}$ ,  $V5 = 28\text{ V}$ .  $I_2$  is the CO pin leakage current ( $I_{COLL}$ ) at that time.

##### (2) CO pin sink current ( $I_{COL}$ )

Set SW5 to ON after setting  $V1 = 5.2\text{ V}$ ,  $V2 = 2.8\text{ V}$ ,  $V3 = 2.5\text{ V}$ ,  $V5 = 0\text{ V}$ .  $I_2$  is the CO pin sink current ( $I_{COL}$ ) at that time.

#### 3.2.2 Active "L"

##### (1) CO pin leakage current ( $I_{COLL}$ )

Set SW5 to ON after setting  $V1 = V2 = V3 = 3.5\text{ V}$ ,  $V5 = 28\text{ V}$ .  $I_2$  is the CO pin leakage current ( $I_{COLL}$ ) at that time.

##### (2) CO pin sink current ( $I_{COL}$ )

Set SW5 to ON after setting  $V1 = 5.2\text{ V}$ ,  $V2 = 2.8\text{ V}$ ,  $V3 = 2.5\text{ V}$ ,  $V5 = 0\text{ V}$ .  $I_2$  is the CO pin sink current ( $I_{COL}$ ) at that time.

### 3.3 S-8223B/D Series

Set SW4 and SW5 to OFF.

#### 3.3.1 CO pin source current ( $I_{COH}$ )

Set SW5 to ON after setting  $V1 = V2 = V3 = 3.5\text{ V}$ ,  $V5 = V_{COH} - 0.5\text{ V}$ .  $I_2$  is the CO pin source current ( $I_{COH}$ ) at that time.

#### 3.3.2 CO pin sink current ( $I_{COL}$ )

Set SW5 to ON after setting  $V1 = V2 = V3 = 3.5\text{ V}$ ,  $V5 = 0.5\text{ V}$ .  $I_2$  is the CO pin sink current ( $I_{COL}$ ) at that time.

### 4. Overcharge detection delay time ( $t_{CU}$ ), overcharge release delay time ( $t_{CL}$ ) (Test circuit 1)

Set SW1 to OFF in CMOS output product of the S-8223A/C Series and in the S-8223B/D Series, and set SW1 to ON in Nch open-drain output product of the S-8223A/C Series.

Increase  $V1$  up to  $5.2\text{ V}$  after setting  $V0 = 0\text{ V}$ ,  $V1 = V2 = V3 = 3.5\text{ V}$ . The overcharge detection delay time ( $t_{CU}$ ) is the time period until the CO pin output inverts. After that, decrease  $V1$  down to  $3.5\text{ V}$ . The overcharge release delay time ( $t_{CL}$ ) is the time period until the CO pin output inverts.

### 5. Overcharge timer reset delay time ( $t_{TR}$ ) (Test circuit 1)

Set SW1 to OFF in CMOS output product of the S-8223A/C Series and in the S-8223B/D Series, and set SW1 to ON in Nch open-drain output product of the S-8223A/C Series.

Increase  $V1$  up to  $5.2\text{ V}$  (first rise), and decrease  $V1$  down to  $3.5\text{ V}$  within the overcharge detection delay time ( $t_{CU}$ ) after setting  $V0 = 0\text{ V}$ ,  $V1 = V2 = V3 = 3.5\text{ V}$ . After that, increase  $V1$  up to  $5.2\text{ V}$  again (second rise), and detect the time period until the CO pin output inverts.

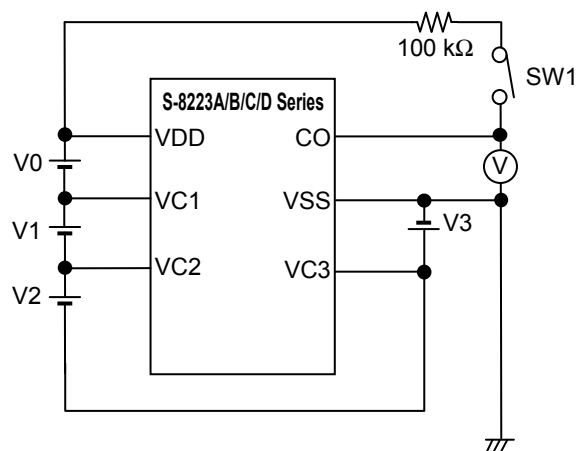
When the period from when  $V1$  has fallen to the second rise is short, CO pin output inverts after  $t_{CU}$  has elapsed since the first rise. If the period is gradually made longer, CO pin output inverts after  $t_{CU}$  has elapsed since the second rise. The overcharge timer reset delay time ( $t_{TR}$ ) is the period from  $V1$  fall until the second rise at that time.

**6. Transition time to test mode ( $t_{TST}$ ) (Test circuit 1)**

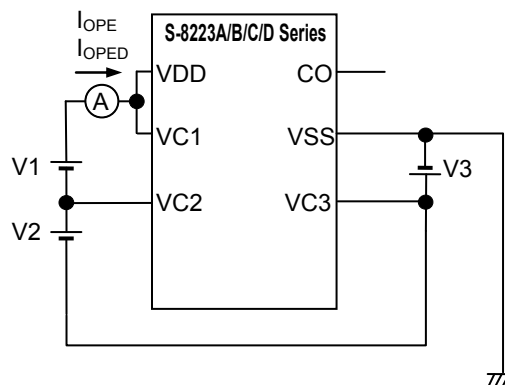
Set SW1 to OFF in CMOS output product of the S-8223A/C Series and in the S-8223B/D Series, and set SW1 to ON in Nch open-drain output product of the S-8223A/C Series.

Increase V0 up to 4.0 V, and decrease V0 again to 0 V after setting V0 = 0 V, V1 = V2 = V3 = 3.5 V.

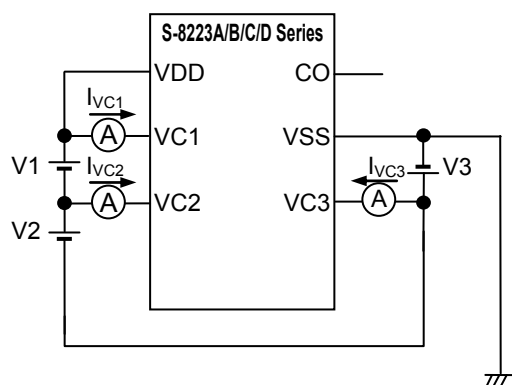
When the period from when V0 was raised to when it has fallen is short, if an overcharge detection operation is performed subsequently, the overcharge detection delay time is  $t_{CU}$ . However, when the period from when V0 is raised to when it has fallen is gradually made longer, the delay time during the subsequent overcharge detection operation is shorter than  $t_{CU}$ . The transition time to test mode ( $t_{TST}$ ) is the period from when V0 was raised to when it has fallen at that time.



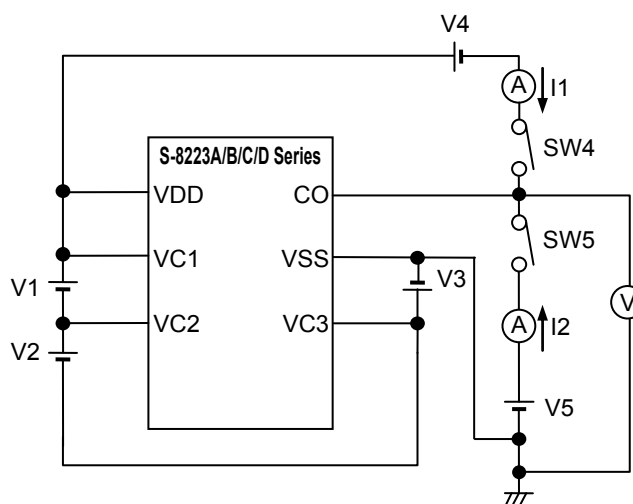
**Figure 5 Test Circuit 1**



**Figure 6 Test Circuit 2**



**Figure 7 Test Circuit 3**



**Figure 8 Test Circuit 4**

## ■ Operation

**Remark** Refer to "■ Battery Protection IC Connection Examples".

### 1. Normal status

If the voltage of each of the batteries is lower than "the overcharge detection voltage ( $V_{CU}$ ) + the overcharge hysteresis voltage ( $V_{HC}$ )", the CO pin output changes to "L" (active "H") or "H" (active "L"). This is called normal status.

### 2. Overcharge status

When the voltage of one of the batteries exceeds  $V_{CU}$  during charging under normal conditions and the status is retained for the overcharge detection delay time ( $t_{CU}$ ) or longer, CO pin output inverts. This status is called overcharge status. Connecting a FET to the CO pin provides charge control and a second protection.

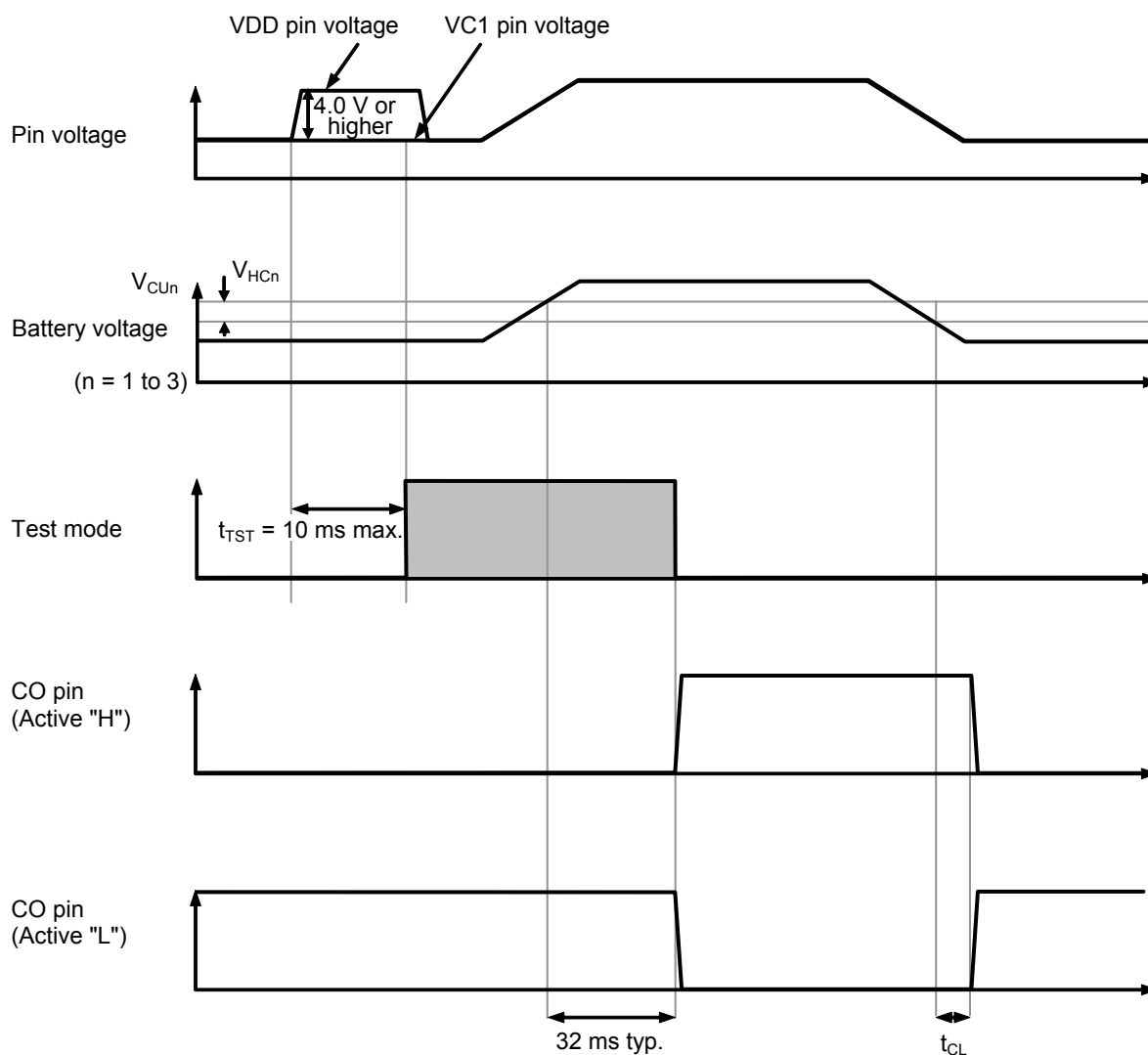
If the voltage of each of the batteries is lower than  $V_{CU} + V_{HC}$  and the status is retained for the overcharge release delay time ( $t_{CL}$ ) or longer, S-8223A/B/C/D Series changes to normal status.

### 3. Overcharge timer reset function

When an overcharge release noise that forces the voltage of one of the batteries temporarily below  $V_{CU}$  is input during  $t_{CU}$  from when  $V_{CU}$  is exceeded to when charging is stopped,  $t_{CU}$  is continuously counted if the time the overcharge release noise persists is shorter than the overcharge timer reset delay time ( $t_{TR}$ ). Under the same conditions, if the time the overcharge release noise persists is  $t_{TR}$  or longer, counting of  $t_{CU}$  is reset once. After that, when  $V_{CU}$  has been exceeded, counting  $t_{CU}$  resumes.

#### 4. Test mode

In the S-8223A/B/C/D Series, the overcharge detection delay time ( $t_{CU}$ ) can be shortened by entering the test mode. The test mode can be set by retaining the VDD pin voltage 4.0 V or more higher than the VC1 pin voltage for at least 10 ms ( $V_1 = V_2 = V_3 = 3.5$  V,  $T_a = +25$  °C). The status is retained by the internal latch and the test mode is retained even if the VDD pin voltage is decreased to the same voltage as that of the VC1 pin. If the CO pin becomes detection status when the delay time has elapsed after overcharge detection, the latch for retaining the test mode is reset and the S-8223A/B/C/D Series exits from the test mode.



- Caution**
1. Set the test mode when no batteries are overcharged.
  2. The overcharge timer reset delay time ( $t_{TR}$ ) is not shortened in the test mode.

Figure 9

## ■ Timing Charts

### 1. Overcharge detection operation

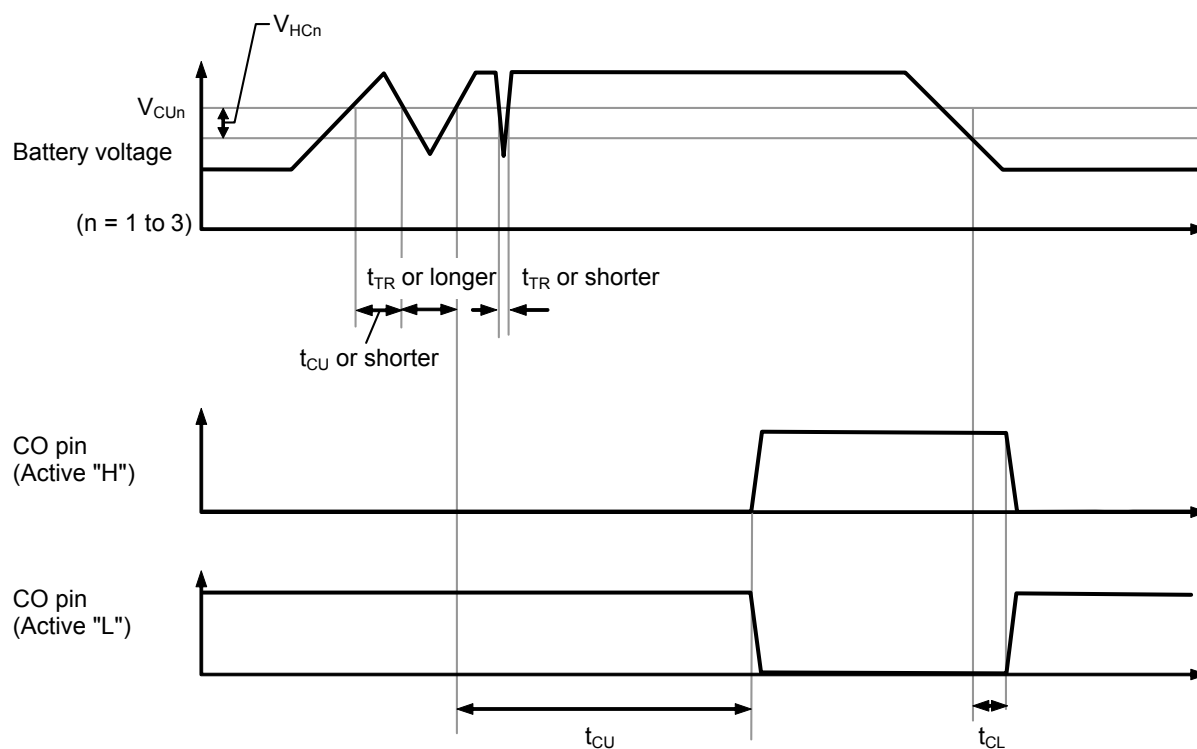


Figure 10



## 2. Overcharge timer reset operation

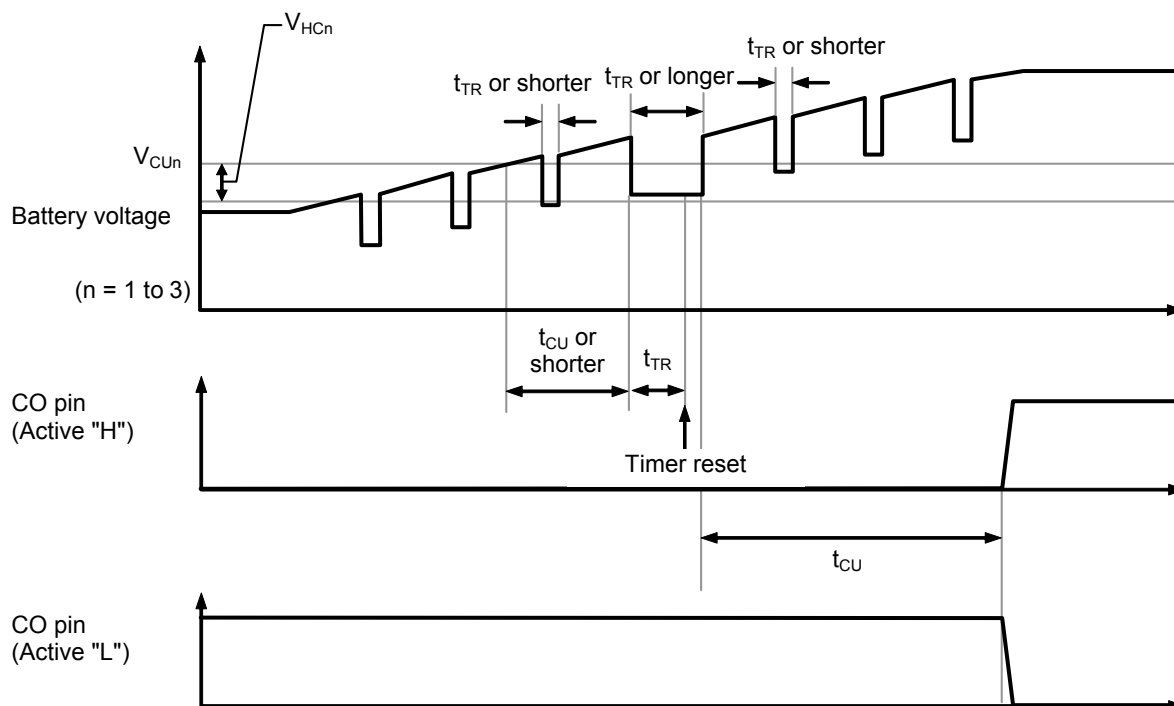
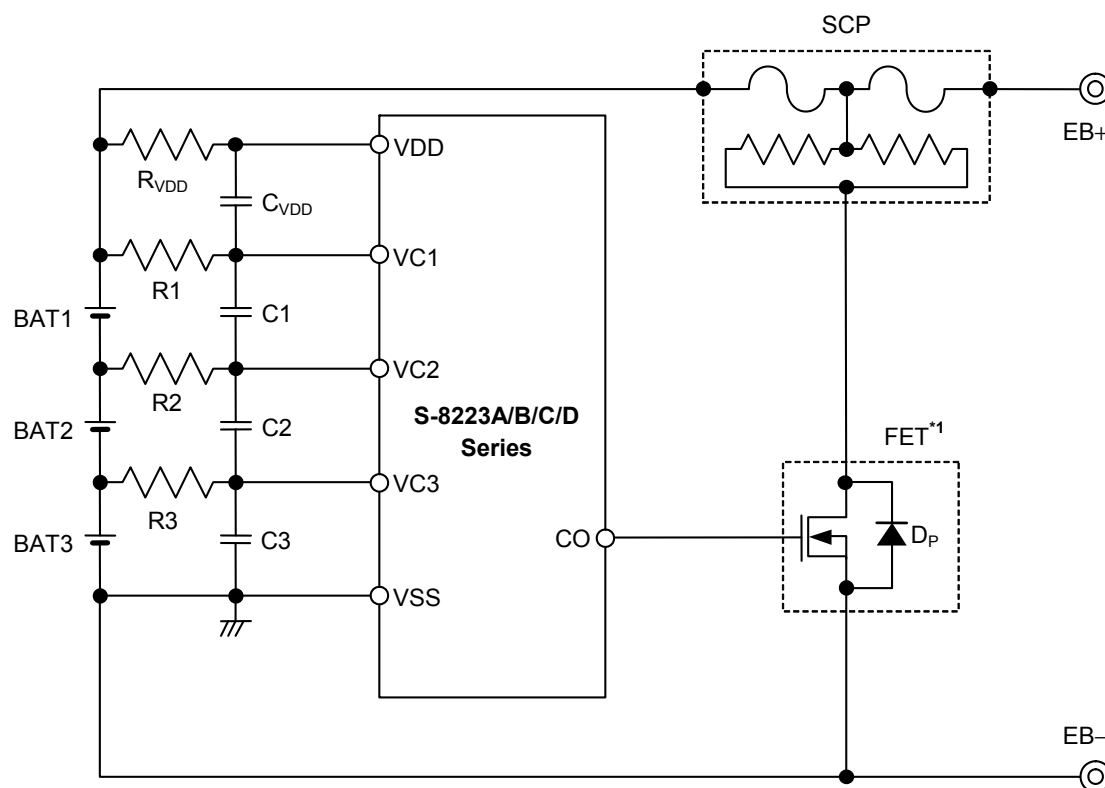


Figure 11

## ■ Battery Protection IC Connection Examples

### 1. 3-serial cell



\*1. The S-8223B/D Series limits its CO pin output voltage to 11.5 V max., so a FET with the gate withstand voltage of 12 V can be used.

Figure 12

Table 10 Constants for External Components

| No. | Part                       | Min. | Typ. | Max. | Unit |
|-----|----------------------------|------|------|------|------|
| 1   | R1 to R3                   | 0.1  | 1    | 10   | kΩ   |
| 2   | C1 to C3, C <sub>VDD</sub> | 0.01 | 0.1  | 1    | μF   |
| 3   | R <sub>VDD</sub>           | 100  | 330  | 1000 | Ω    |

**Caution** 1. The above constants are subject to change without prior notice.

2. It has not been confirmed whether the operation is normal or not in circuits other than the above example of connection. In addition, the example of connection shown above and the constant will not guarantee successful operation. Perform thorough evaluation using the actual application to set the constant.

3. Set the same constants to R1 to R3, and to C1 to C3 and C<sub>VDD</sub>.

4. Since the CO pin may become detection status transiently when the battery is being connected, be sure to connect the positive terminal of BAT1 last in order to prevent the protection fuse from cutoff.

## 2. 2-serial cell

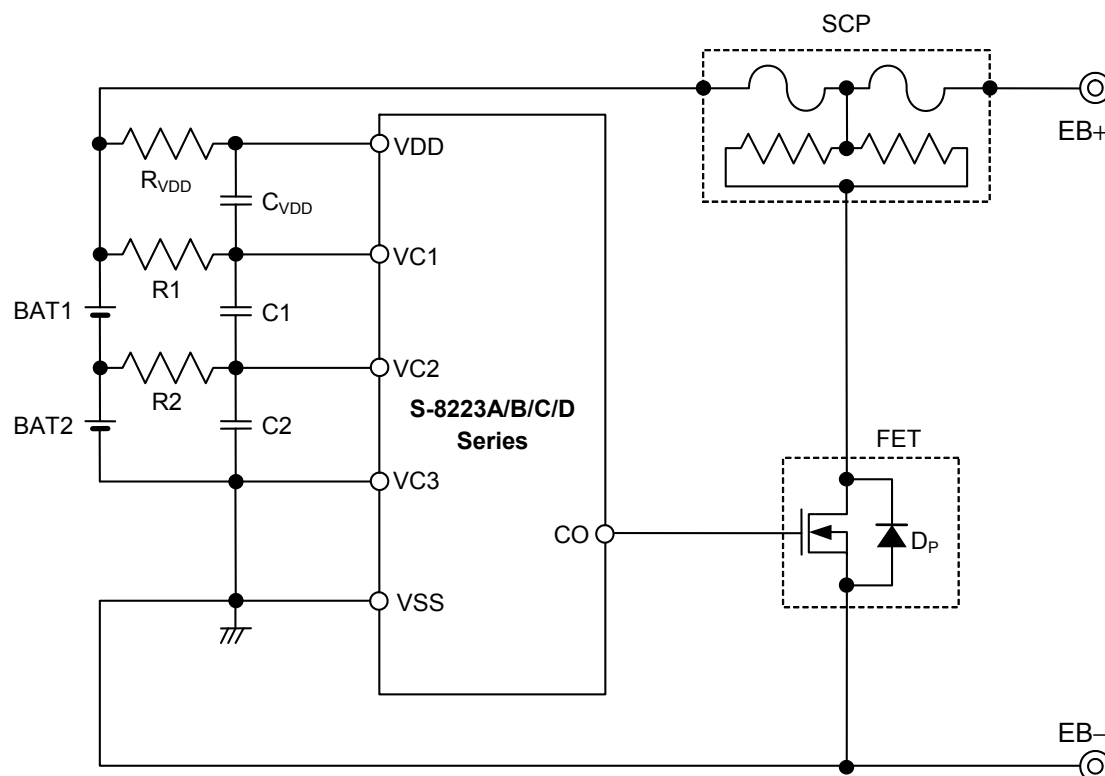


Figure 13

Table 11 Constants for External Components

| No. | Part                     | Min. | Typ. | Max. | Unit       |
|-----|--------------------------|------|------|------|------------|
| 1   | R1, R2                   | 0.1  | 1    | 10   | k $\Omega$ |
| 2   | C1, C2, C <sub>VDD</sub> | 0.01 | 0.1  | 1    | $\mu$ F    |
| 3   | R <sub>VDD</sub>         | 100  | 330  | 1000 | $\Omega$   |

- Caution**
1. The above constants are subject to change without prior notice.
  2. It has not been confirmed whether the operation is normal or not in circuits other than the above example of connection. In addition, the example of connection shown above and the constant will not guarantee successful operation. Perform thorough evaluation using the actual application to set the constant.
  3. Set the same constants to R1, R2, and to C1, C2 and C<sub>VDD</sub>.
  4. Since the CO pin may become detection status transiently when the battery is being connected, be sure to connect the positive terminal of BAT1 last in order to prevent the protection fuse from cutoff.

**[For SCP, contact]**

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Gate City Osaki East Tower 8F, 1-11-2

Osaki, Shinagawa-ku, Tokyo, 141-0032, Japan

TEL +81-3-5435-3946

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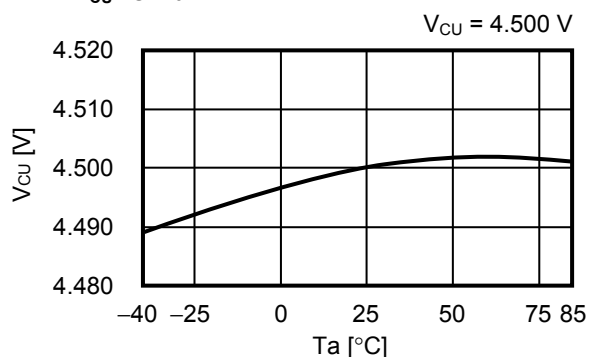
**■ Precaution**

- Do not connect batteries charged with  $V_{CU} + V_{HC}$  or higher.
- If the connected batteries include a battery charged with  $V_{CU} + V_{HC}$  or higher, the S-8223A/B/C/D Series may become overcharge status after all pins are connected.
- In some application circuits, even if an overcharged battery is not included, the order of connecting batteries may be restricted to prevent transient output of the CO pin detection pulses when the batteries are connected. Perform thorough evaluation with the actual application circuit.
- Before the battery connection, short-circuit the battery side pins  $R_{VDD}$  and R1, shown in the figures in "■ **Battery Protection IC Connection Examples**".
- The application conditions for the input voltage, output voltage, and load current should not exceed the power dissipation.
- Do not apply to this IC an electrostatic discharge 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 of patents owned by a third party by products including this IC.

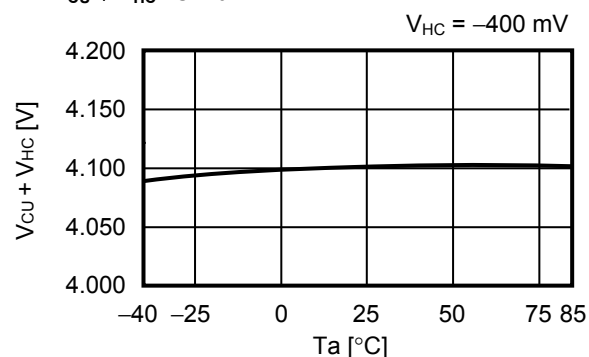
## ■ Characteristics (Typical Data)

### 1. Detection voltage

1. 1  $V_{CU}$  vs.  $T_a$

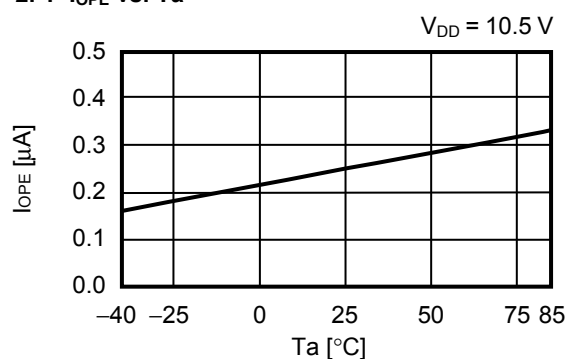


1. 2  $V_{CU} + V_{HC}$  vs.  $T_a$

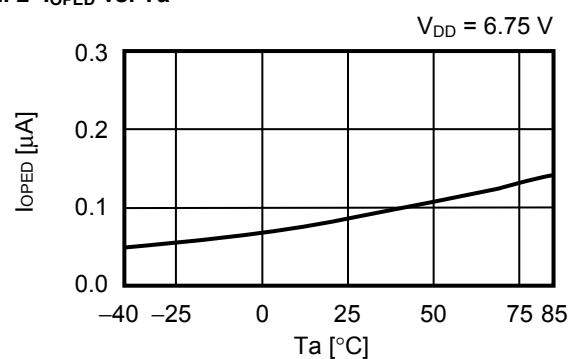


### 2. Current consumption

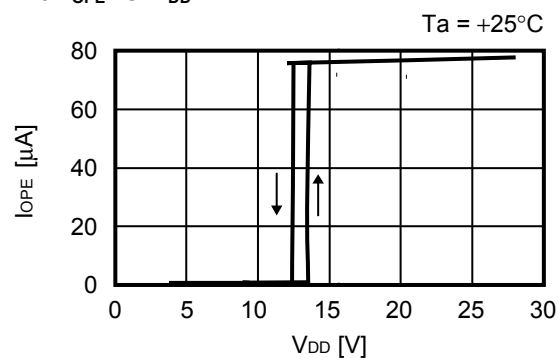
2. 1  $I_{OPE}$  vs.  $T_a$



2. 2  $I_{OPED}$  vs.  $T_a$

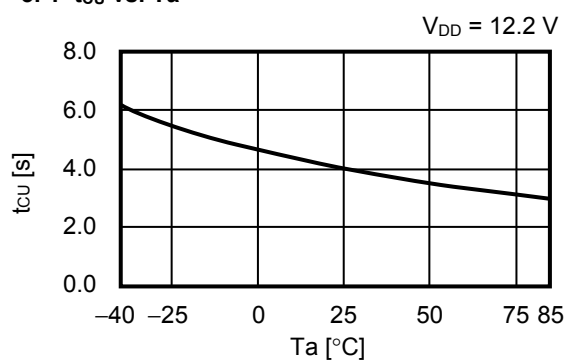


2. 3  $I_{OPE}$  vs.  $V_{DD}$



### 3. Delay time

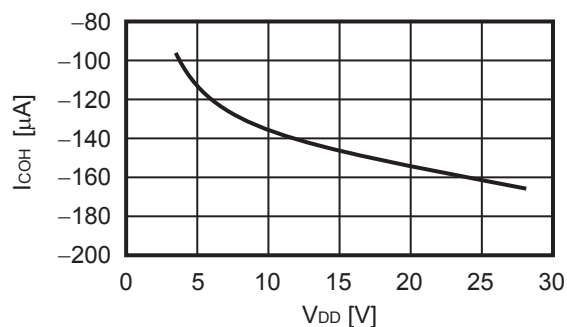
3. 1  $t_{CU}$  vs.  $T_a$



## 4. Output current

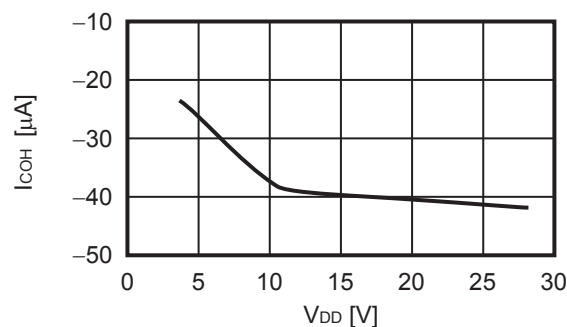
### 4. 1 $I_{COH}$ vs. $V_{DD}$ (S-8223A/C Series)

$T_a = +25^{\circ}\text{C}$



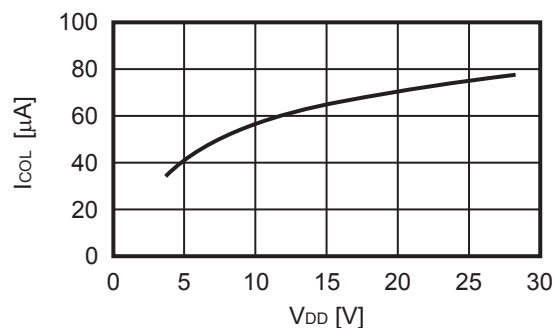
### 4. 2 $I_{COH}$ vs. $V_{DD}$ (S-8223B/D Series)

$T_a = +25^{\circ}\text{C}$



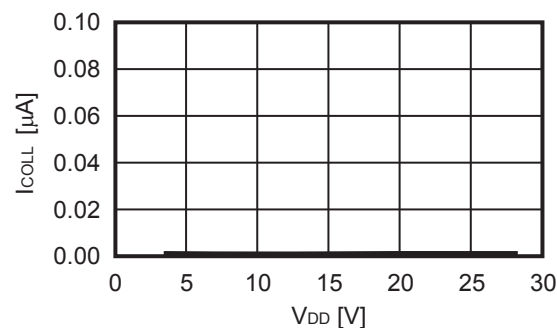
### 4. 3 $I_{COL}$ vs. $V_{DD}$

$T_a = +25^{\circ}\text{C}$



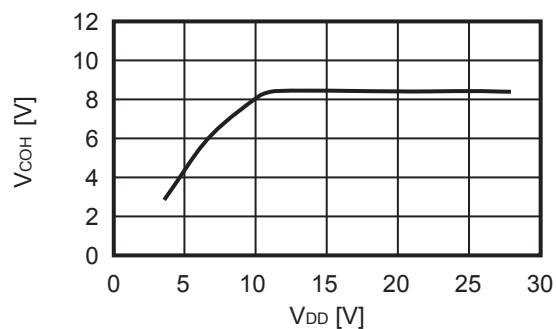
### 4. 4 $I_{COLL}$ vs. $V_{DD}$

$T_a = +25^{\circ}\text{C}$



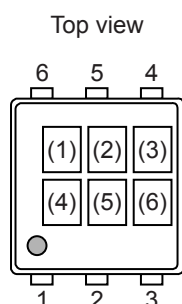
## 5. Output voltage

### 5. 1 $V_{COH}$ vs. $V_{DD}$



## ■ Marking Specifications

### 1. SNT-6A



(1) to (3): Product code (refer to **Product name vs. Product code**)  
 (4) to (6): Lot number

#### Product name vs. Product code

##### 1.1 S-8223A Series

| Product name    | Product code |     |     |
|-----------------|--------------|-----|-----|
|                 | (1)          | (2) | (3) |
| S-8223AAA-I6T1U | 5            | Q   | A   |
| S-8223AAB-I6T1U | 5            | Q   | D   |
| S-8223AAC-I6T1U | 5            | Q   | E   |
| S-8223AAD-I6T1U | 5            | Q   | F   |
| S-8223AAE-I6T1U | 5            | Q   | G   |
| S-8223AAF-I6T1U | 5            | Q   | H   |
| S-8223AAG-I6T1U | 5            | Q   | I   |
| S-8223AAH-I6T1U | 5            | Q   | J   |
| S-8223AAI-I6T1U | 5            | Q   | K   |
| S-8223AAJ-I6T1U | 5            | Q   | L   |

##### 1.2 S-8223B Series

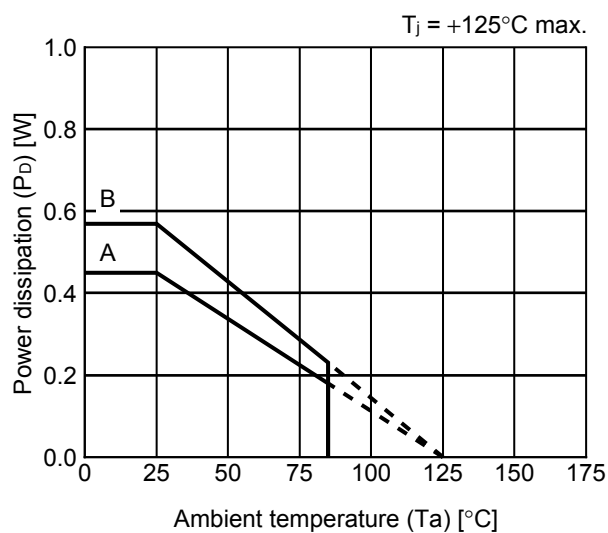
| Product name    | Product code |     |     |
|-----------------|--------------|-----|-----|
|                 | (1)          | (2) | (3) |
| S-8223BAA-I6T1U | 5            | Q   | W   |

##### 1.3 S-8223C Series

| Product name    | Product code |     |     |
|-----------------|--------------|-----|-----|
|                 | (1)          | (2) | (3) |
| S-8223CAA-I6T1U | 5            | Q   | M   |
| S-8223CAB-I6T1U | 5            | Q   | N   |
| S-8223CAC-I6T1U | 5            | Q   | O   |
| S-8223CAD-I6T1U | 5            | Q   | P   |
| S-8223CAE-I6T1U | 5            | Q   | Q   |
| S-8223CAF-I6T1U | 5            | Q   | R   |
| S-8223CAG-I6T1U | 5            | Q   | S   |
| S-8223CAH-I6T1U | 5            | Q   | T   |
| S-8223CAI-I6T1U | 5            | Q   | U   |
| S-8223CAJ-I6T1U | 5            | Q   | V   |
| S-8223CAK-I6T1U | 5            | Q   | X   |

## ■ Power Dissipation

### SNT-6A



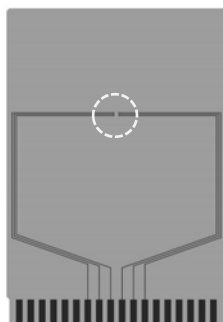
| Board | Power Dissipation ( $P_D$ ) |
|-------|-----------------------------|
| A     | 0.45 W                      |
| B     | 0.57 W                      |
| C     | —                           |
| D     | —                           |
| E     | —                           |



# SNT-6A Test Board

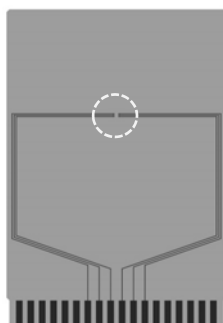
(1) Board A

 IC Mount Area



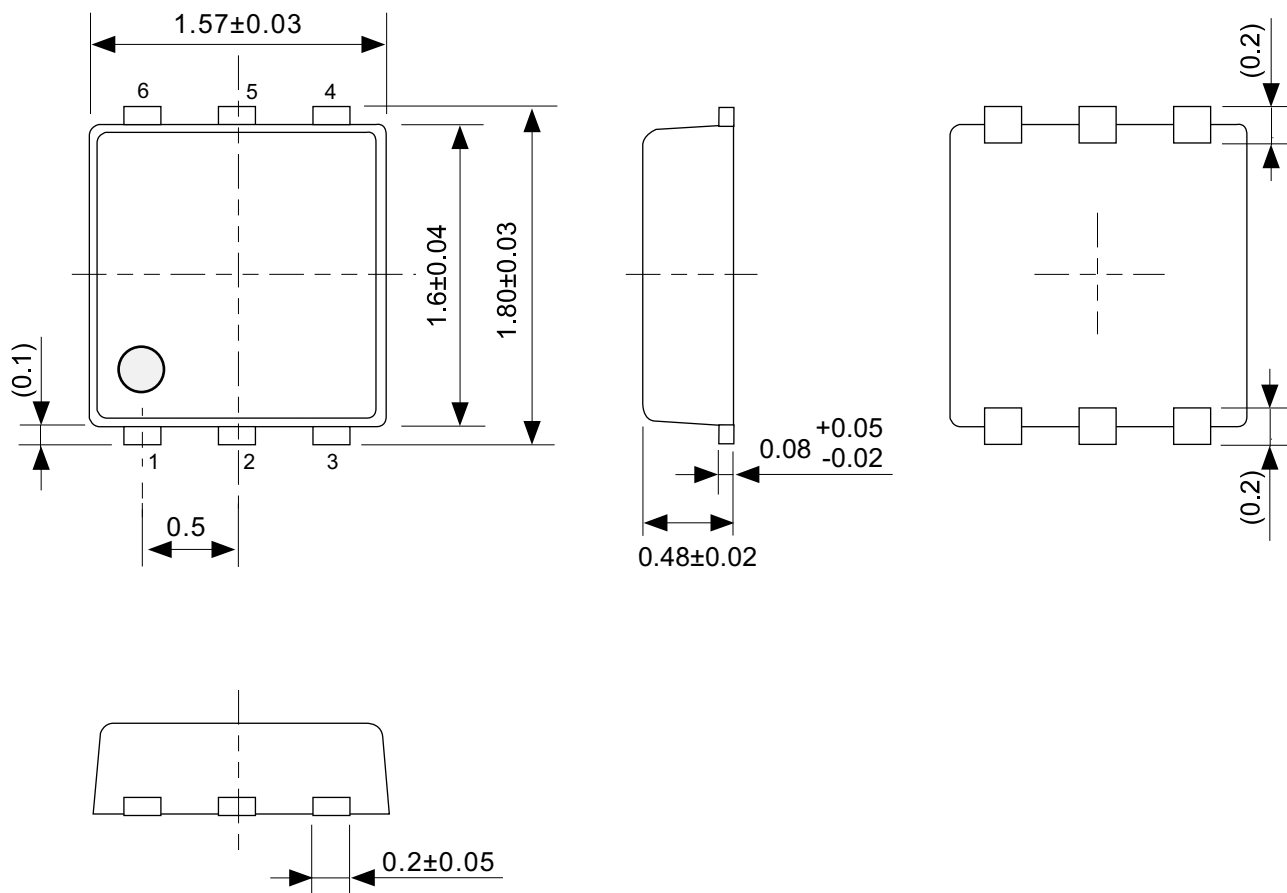
| Item                        |   | Specification                               |
|-----------------------------|---|---|
| Size [mm]                   |   | 114.3 x 76.2 x t1.6                         |
| Material                    |   | FR-4  |
| Number of copper foil layer |   | 2   |
| Copper foil layer [mm]      | 1 | Land pattern and wiring for testing: t0.070 |
|                             | 2 | -   |
|                             | 3 | -   |
|                             | 4 | 74.2 x 74.2 x t0.070                        |
| Thermal via                 |   | -   |

(2) Board B




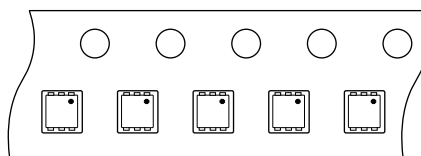
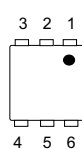
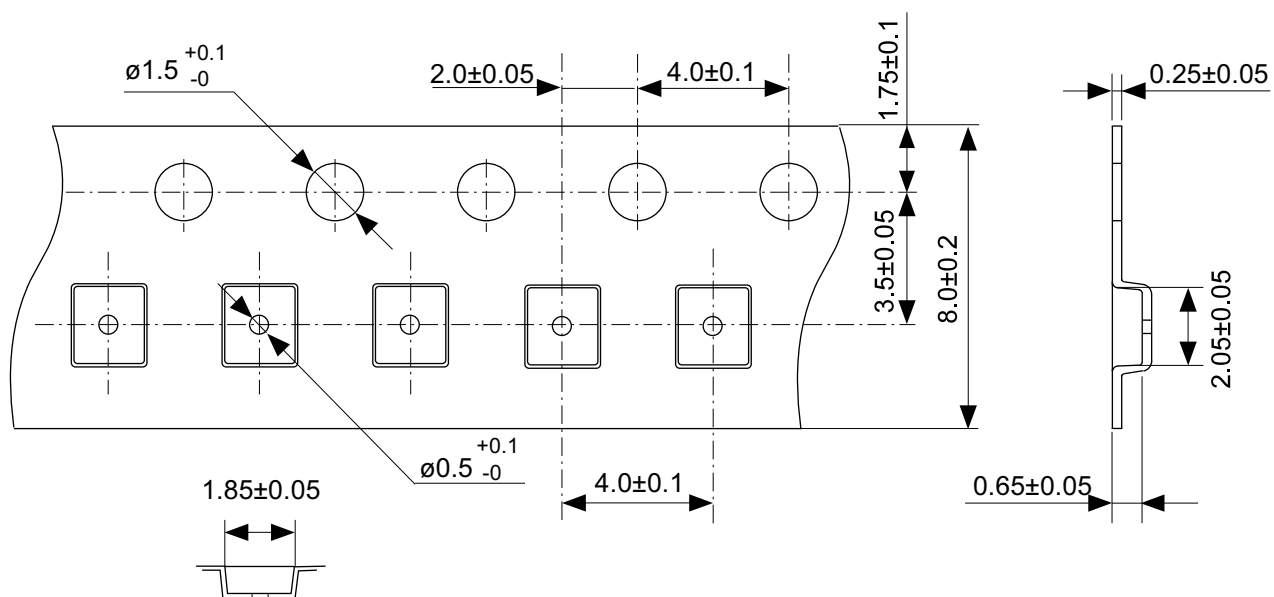
| Item                        |   | Specification                               |
|-----------------------------|---|---|
| Size [mm]                   |   | 114.3 x 76.2 x t1.6                         |
| Material                    |   | FR-4  |
| Number of copper foil layer |   | 4   |
| Copper foil layer [mm]      | 1 | Land pattern and wiring for testing: t0.070 |
|                             | 2 | 74.2 x 74.2 x t0.035                        |
|                             | 3 | 74.2 x 74.2 x t0.035                        |
|                             | 4 | 74.2 x 74.2 x t0.070                        |
| Thermal via                 |   | -   |

No. SNT6A-A-Board-SD-1.0



No. PG006-A-P-SD-2.1

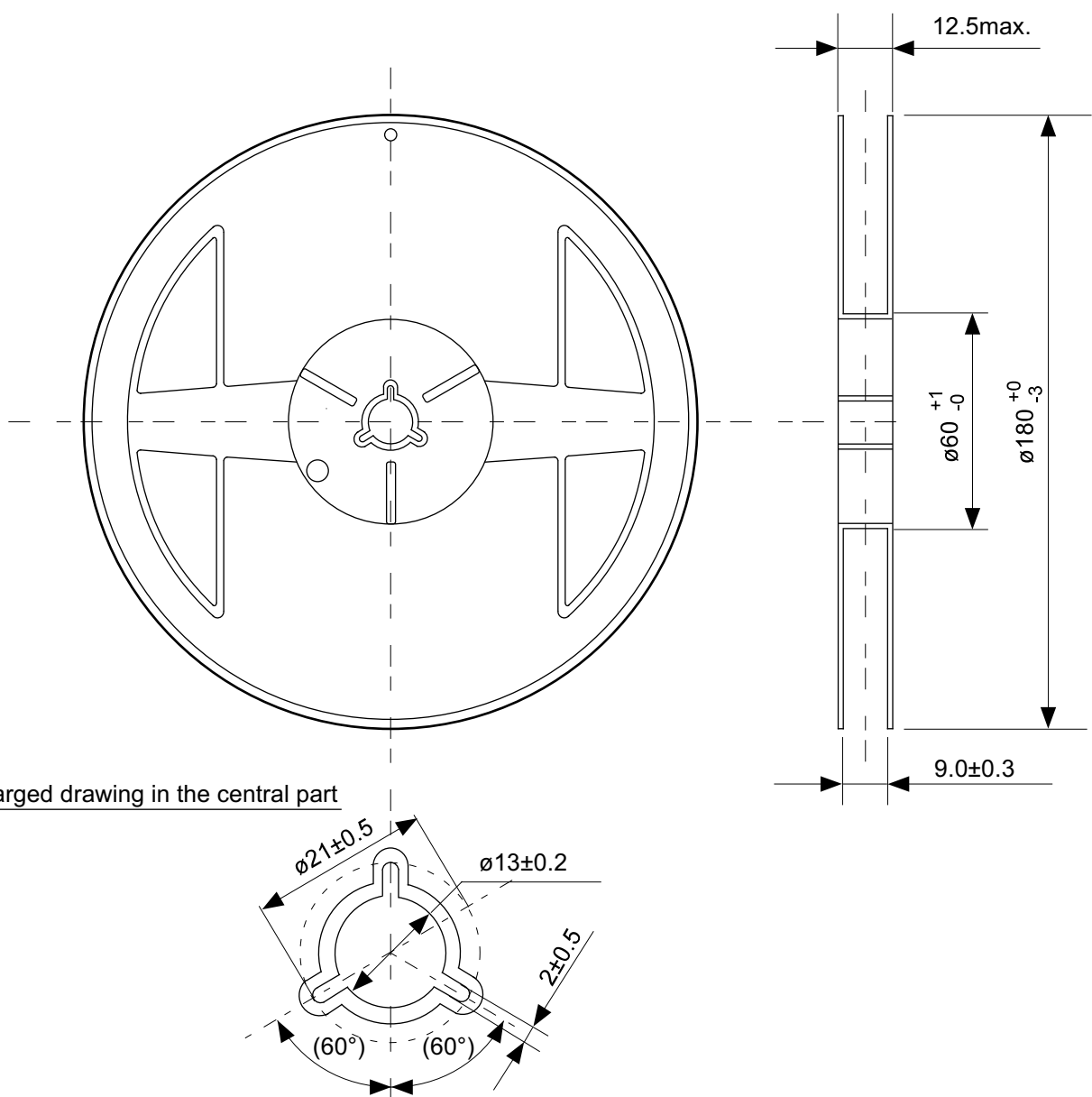
|            |   |
|------------|---|
| TITLE      | SNT-6A-A-PKG Dimensions   |
| No.        | PG006-A-P-SD-2.1  |
| ANGLE      |  |
| UNIT       | mm  |
|            |   |
| ABLIC Inc. |   |



Feed direction

No. PG006-A-C-SD-2.0

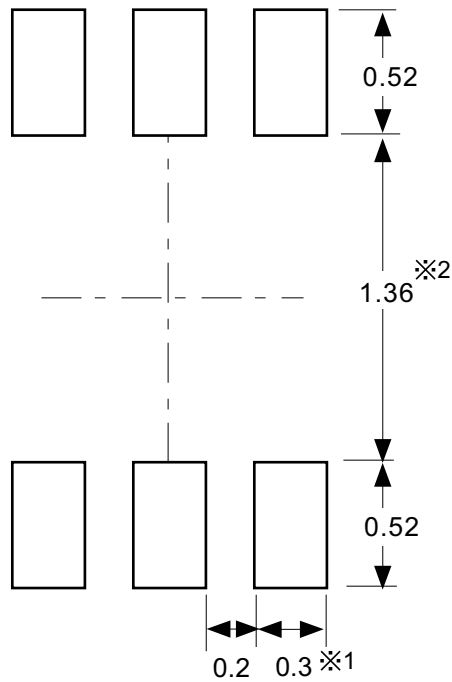
|            |                       |
|------------|-----------------------|
| TITLE      | SNT-6A-A-Carrier Tape |
| No.        | PG006-A-C-SD-2.0      |
| ANGLE      |                       |
| UNIT       | mm                    |
|            |                       |
| ABLIC Inc. |                       |



Enlarged drawing in the central part

No. PG006-A-R-SD-1.0

|            |                  |      |       |
|------------|------------------|------|-------|
| TITLE      | SNT-6A-A-Reel    |      |       |
| No.        | PG006-A-R-SD-1.0 |      |       |
| ANGLE      |                  | QTY. | 5,000 |
| UNIT       | mm               |      |       |
|            |                  |      |       |
| ABLIC Inc. |                  |      |       |



※1. ランドパターンの幅に注意してください (0.25 mm min. / 0.30 mm typ.).

※2. パッケージ中央にランドパターンを広げないでください (1.30 mm ~ 1.40 mm)。

- 注意
1. パッケージのモールド樹脂下にシルク印刷やハンダ印刷などしないでください。
  2. パッケージ下の配線上のソルダーレジストなどの厚みをランドパターン表面から0.03 mm以下にしてください。
  3. マスク開口サイズと開口位置はランドパターンと合わせてください。
  4. 詳細は“SNTパッケージ活用の手引き”を参照してください。

※1. Pay attention to the land pattern width (0.25 mm min. / 0.30 mm typ.).

※2. Do not widen the land pattern to the center of the package ( 1.30 mm ~ 1.40 mm ).

- Caution**
1. Do not do silkscreen printing and solder printing under the mold resin of the package.
  2. The thickness of the solder resist on the wire pattern under the package should be 0.03 mm or less from the land pattern surface.
  3. Match the mask aperture size and aperture position with the land pattern.
  4. Refer to "SNT Package User's Guide" for details.

※1. 请注意焊盘模式的宽度 (0.25 mm min. / 0.30 mm typ.).

※2. 请勿向封装中间扩展焊盘模式 (1.30 mm ~ 1.40 mm)。

- 注意
1. 请勿在树脂型封装的下面印刷丝网、焊锡。
  2. 在封装下、布线上的阻焊膜厚度 (从焊盘模式表面起) 请控制在 0.03 mm 以下。
  3. 钢网的开口尺寸和开口位置请与焊盘模式对齐。
  4. 详细内容请参阅 "SNT 封装的应用指南"。

No. PG006-A-L-SD-4.1

|            |                                  |
|------------|----------------------------------|
| TITLE      | SNT-6A-A<br>-Land Recommendation |
| No.        | PG006-A-L-SD-4.1                 |
| ANGLE      |                                  |
| UNIT       | mm                               |
|            |                                  |
| ABLIC Inc. |                                  |

## Disclaimers (Handling Precautions)

1. All the information described herein (product data, specifications, figures, tables, programs, algorithms and application circuit examples, etc.) is current as of publishing date of this document and is subject to change without notice.
2. The circuit examples and the usages described herein are for reference only, and do not guarantee the success of any specific mass-production design.  
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3. ABLIC Inc. is not responsible for damages caused by the incorrect information described herein.
4. Be careful to use the products within their specified ranges. Pay special attention to the absolute maximum ratings, operation voltage range and electrical characteristics, etc.  
ABLIC Inc. is not responsible for damages caused by failures and / or accidents, etc. that occur due to the use of the products outside their specified ranges.
5. When using the products, confirm their applications, and the laws and regulations of the region or country where they are used and verify suitability, safety and other factors for the intended use.
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8. The products are not designed to be used as part of any device or equipment that may affect the human body, human life, or assets (such as medical equipment, disaster prevention systems, security systems, combustion control systems, infrastructure control systems, vehicle equipment, traffic systems, in-vehicle equipment, aviation equipment, aerospace equipment, and nuclear-related equipment), excluding when specified for in-vehicle use or other uses. Do not apply the products to the above listed devices and equipments without prior written permission by ABLIC Inc. Especially, the products cannot be used for life support devices, devices implanted in the human body and devices that directly affect human life, etc.  
Prior consultation with our sales office is required when considering the above uses.  
ABLIC Inc. is not responsible for damages caused by unauthorized or unspecified use of our products.
9. Semiconductor products may fail or malfunction with some probability.  
The user of the products should therefore take responsibility to give thorough consideration to safety design including redundancy, fire spread prevention measures, and malfunction prevention to prevent accidents causing injury or death, fires and social damage, etc. that may ensue from the products' failure or malfunction.  
The entire system must be sufficiently evaluated and applied on customer's own responsibility.
10. The products are not designed to be radiation-proof. The necessary radiation measures should be taken in the product design by the customer depending on the intended use.
11. The products do not affect human health under normal use. However, they contain chemical substances and heavy metals and should therefore not be put in the mouth. The fracture surfaces of wafers and chips may be sharp. Be careful when handling these with the bare hands to prevent injuries, etc.
12. When disposing of the products, comply with the laws and ordinances of the country or region where they are used.
13. The information described herein contains copyright information and know-how of ABLIC Inc.  
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14. For more details on the information described herein, contact our sales office.

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