

## CONTENTS

|                               |    |
|-------------------------------|----|
| Features.....                 | 1  |
| Selection Guide.....          | 1  |
| Block Diagram.....            | 2  |
| Pin Assignment.....           | 3  |
| Functions of Pins.....        | 3  |
| Absolute Maximum Ratings..... | 3  |
| Electrical Characteristics..  | 4  |
| Measurement Circuits.....     | 5  |
| Operation.....                | 8  |
| Operating Timing Chart.....   | 9  |
| Battery Protection IC.....    | 10 |
| Handling Precautions.....     | 10 |
| Dimensions.....               | 11 |
| Markings.....                 | 11 |
| Taping.....                   | 12 |
| Characteristics.....          | 13 |

The S-8491 is a series of lithium-ion rechargeable battery protection ICs incorporating high-accuracy voltage detectors and a delay circuit. This series is suitable for protecting a single-cell pack.

## ■ Features

### (1) Built-in high-accuracy voltage detection circuits:

- ① Excess charge detection voltage  $V_{CU}$  ...  $4.35 \pm 0.05$  V to  $4.25 \pm 0.05$  V/0.05 V step
- ② Excess charge release voltage  $V_{CD}$  .....  $4.15 \pm 0.13$  V to  $3.95 \pm 0.13$  V/0.05 V step
  - \* The difference between the excess charge detection voltage and the excess charge release voltage can be selected in the range of 0.2 V to 0.3 V.
- ③ Excess discharge detection voltage  $V_{DD}$  .....  $2.30 \pm 0.10$  V
- ④ Excess discharge release voltage  $V_{DU}$  .....  $3.00 \pm 0.15$  V to  $2.40 \pm 0.15$  V/0.10 V step
- ⑤ Excess current detection voltage  $V_{IOV}$  .....  $0.20 \pm 0.06$  V

### (2) Built-in delay circuit

The excess charge, excess discharge or excess current is detected with delay.

### (3) Ultra-low current consumption

Operation: 15.0  $\mu$ A max. (+ 25 °C)  
Power down: 0.48  $\mu$ A max. (+ 25 °C)

### (4) SOT - 89 - 5 package

## ■ Selection Guide

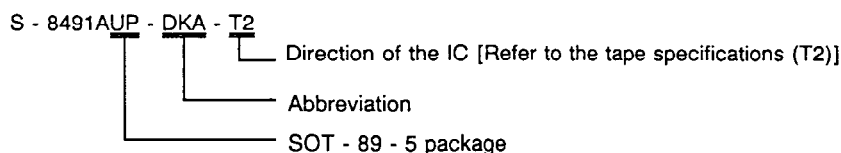


Table 1

| Product \ Item   | Excess charge detection voltage | Excess charge release voltage | Excess discharge release voltage |
|------------------|---------------------------------|-------------------------------|----------------------------------|
| S-8491AUP-DKA-T2 | $4.30 \pm 0.05$ V               | $4.00 \pm 0.13$ V             | $3.00 \pm 0.15$ V                |
| S-8491BUP-DKB-T2 | $4.35 \pm 0.05$ V               | $4.10 \pm 0.13$ V             | $3.00 \pm 0.15$ V                |
| S-8491CUP-DKC-T2 | $4.25 \pm 0.05$ V               | $4.05 \pm 0.13$ V             | $2.70 \pm 0.15$ V                |
| S-8491DUP-DKD-T2 | $4.25 \pm 0.05$ V               | $4.05 \pm 0.13$ V             | $2.40 \pm 0.15$ V                |

Characteristics not specified in Table 1 apply commonly to the S-8491AUP/BUP/CUP/DUP.

■ Block Diagram

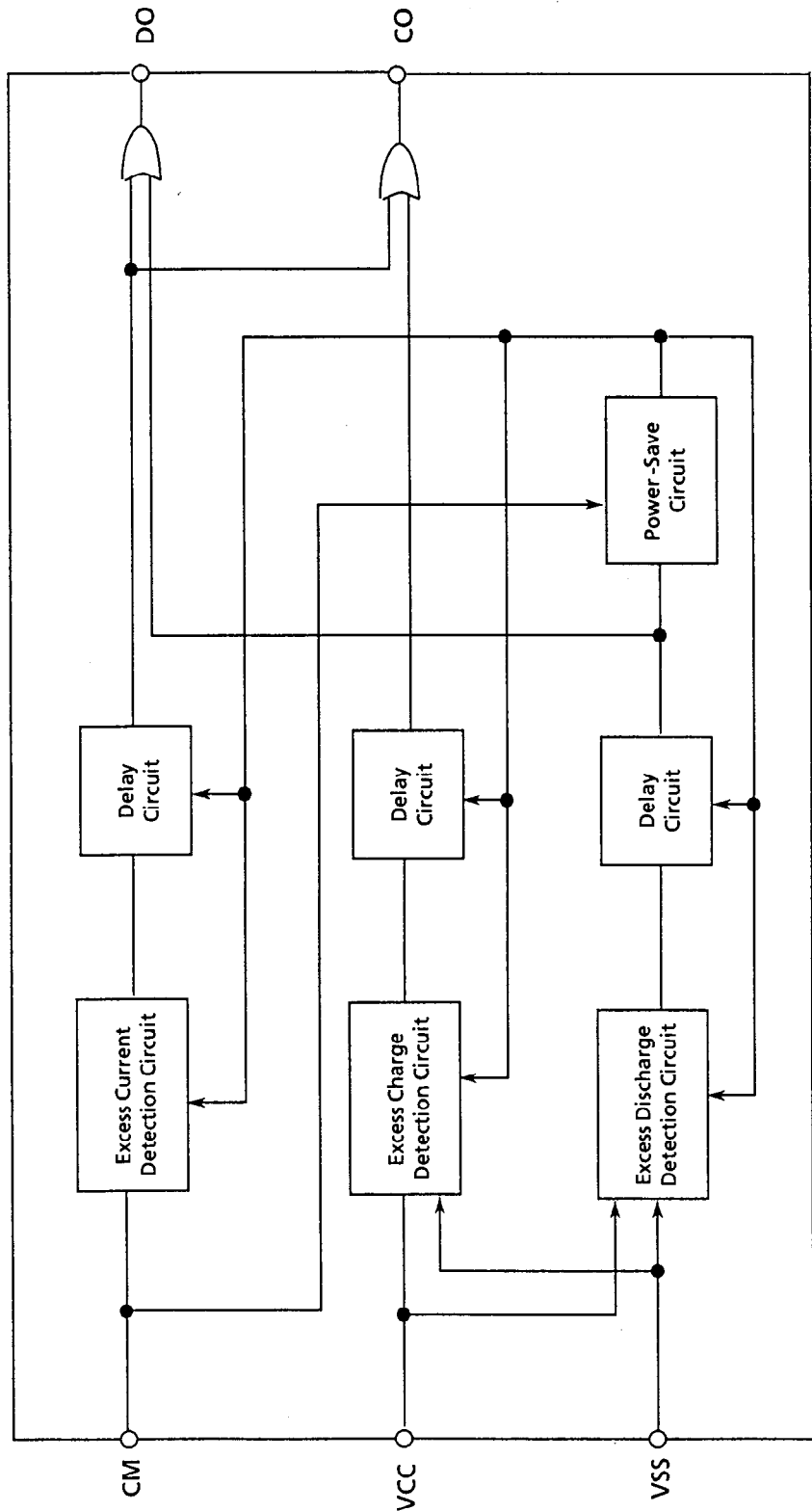


Figure 1

## Pin Assignment

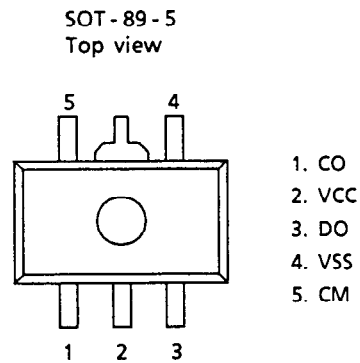


Figure 2

## Functions of Pins

- VCC (Pin No. 2) . . . . Input  
Power supply pin at the positive side of the IC. :
- VSS (Pin No. 4) . . . . Input  
Power supply pin at the negative side of the IC.
- DO (Pin No. 3) . . . . Output (CMOS)  
Gate connection pin for the discharge control Nch-FET. It turns OFF the gate during excess charge or excess current, whereas it turns ON the gate in the excess charge or the normal region.
- CO (Pin No. 1) . . . . Output (Pch open-drain)  
Gate connection pin for the charge control Nch-FET. This pin turns ON the gate in the excess current region, whereas it turns ON the gate in the normal or excess discharge region.
- CM (Pin No. 5) . . . . Input  
Voltage detection pin (between CM and VSS). Detects the discharge current value of the battery due to a drop in the voltage of the FET.

## Absolute Maximum Ratings

Table 2

Ta = 25°C

| Item                            | Symbol           | Ratings                                        | Unit |
|---------------------------------|------------------|------------------------------------------------|------|
| Input voltage between VCC - VSS | V <sub>DS</sub>  | V <sub>SS</sub> - 0.3 to + 18                  | V    |
| Input voltage between VCC - CM  | V <sub>CM</sub>  | V <sub>CC</sub> + 0.3 to - 18                  |      |
| Input voltage between DO - VSS  | V <sub>DOS</sub> | V <sub>SS</sub> - 0.3 to V <sub>CC</sub> + 0.3 | V    |
| Input voltage between VCC - CO  | V <sub>COB</sub> | V <sub>CC</sub> + 0.3 to - 18                  |      |
| Power dissipation               | PD               | 500                                            | mW   |
| Operating temperature range     | T <sub>opr</sub> | - 20 to + 60                                   | °C   |
| Storage temperature range       | T <sub>stg</sub> | - 40 to + 125                                  | °C   |

■ Electrical Characteristics

**Table 3**

Ta = 25°C

| Item                                                          | Symbol             | Conditions        |     | Min.                  | Typ. | Max.                  | Unit  |
|---------------------------------------------------------------|--------------------|-------------------|-----|-----------------------|------|-----------------------|-------|
| Excess charge detection voltage                               | V <sub>CU</sub>    | Measurement 1     | AUP | 4.25                  | 4.30 | 4.35                  | V     |
|                                                               |                    |                   | BUP | 4.30                  | 4.35 | 4.40                  |       |
|                                                               |                    |                   | CUP | 4.20                  | 4.25 | 4.30                  |       |
|                                                               |                    |                   | DUP | 4.20                  | 4.25 | 4.30                  |       |
| Excess charge release voltage                                 | V <sub>CD</sub>    | Measurement 1     | AUP | 3.87                  | 4.00 | 4.13                  |       |
|                                                               |                    |                   | BUP | 3.97                  | 4.10 | 4.23                  |       |
|                                                               |                    |                   | CUP | 3.92                  | 4.05 | 4.18                  |       |
|                                                               |                    |                   | DUP | 3.92                  | 4.05 | 4.18                  |       |
| Excess discharge detection voltage                            | V <sub>DD</sub>    | Measurement 1     |     | 2.20                  | 2.30 | 2.40                  |       |
| Excess discharge release voltage                              | V <sub>DU</sub>    | Measurement 1     | AUP | 2.85                  | 3.00 | 3.15                  |       |
|                                                               |                    |                   | BUP | 2.85                  | 3.00 | 3.15                  |       |
|                                                               |                    |                   | CUP | 2.55                  | 2.70 | 2.85                  |       |
|                                                               |                    |                   | DUP | 2.25                  | 2.40 | 2.55                  |       |
| Excess current detection voltage                              | V <sub>IOV</sub>   | Measurement 6     |     | 0.14                  | 0.20 | 0.26                  |       |
| Temperature coefficient of the detection voltage              | T <sub>COE</sub>   | Ta = - 20 to + 60 |     | - 1.5                 | —    | + 1.5                 | mV/°C |
| Delay time of excess charge detection                         | T <sub>CU</sub>    | Measurement 2     |     | 0.5                   | —    | 5.0                   | ms    |
| Delay time of excess discharge detection                      | T <sub>DD</sub>    | Measurement 2     |     | 0.5                   | —    | 5.0                   |       |
| Delay time of excess current detection                        | T <sub>OFF</sub>   | Measurement 2     |     | 0.5                   | —    | 5.0                   |       |
| Input voltage between V <sub>CC</sub> and V <sub>SS</sub>     | V <sub>DS</sub>    | —                 |     | - 0.3                 | —    | 16                    | V     |
| Input voltage between V <sub>CC</sub> and CM                  | V <sub>CM</sub>    | Note 1            |     | + 0.3                 | —    | - 16                  |       |
| Operating voltage between V <sub>CC</sub> and V <sub>SS</sub> | V <sub>DSOP</sub>  | —                 |     | 2.0                   | —    | 16                    |       |
| Normal operating current consumption                          | I <sub>OPE</sub>   | Measurement 3     |     | —                     | 3.50 | 15                    | μA    |
| Power-down current consumption                                | I <sub>PDN</sub>   | Measurement 3     |     | —                     | 0.25 | 0.48                  |       |
| DO 'H' voltage                                                | V <sub>DO(H)</sub> | Measurement 4     |     | V <sub>CC</sub> - 0.5 | —    | —                     | V     |
| DO 'L' voltage                                                | V <sub>DO(L)</sub> | Measurement 4     |     | —                     | —    | V <sub>SS</sub> + 0.1 |       |
| CO 'H' voltage                                                | V <sub>CO(H)</sub> | Measurement 5     |     | V <sub>CC</sub> - 0.5 | —    | —                     |       |

Note 1: The V<sub>CC</sub> pin-based voltage supplied to the CM pin.

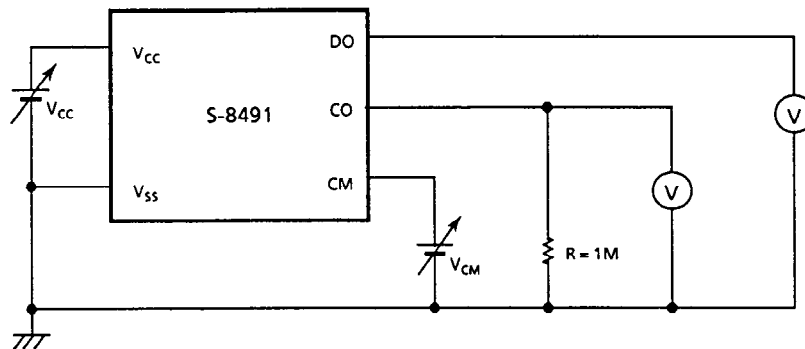
Table 4

Ta = -20 to 60 °C

| Item                                         | Symbol             | Conditions      | Min.                  | Typ. | Max.                  | Unit  |
|----------------------------------------------|--------------------|-----------------|-----------------------|------|-----------------------|-------|
| Temperature coefficient of detection voltage | T <sub>COE</sub>   | Ta = -20 to +60 | -1.5                  | —    | +1.5                  | mV/°C |
| Delay time of excess charge detection        | T <sub>CU</sub>    | Measurement 2   | 0.5                   | —    | 5.0                   | ms    |
| Delay time of excess discharge detection     | T <sub>DD</sub>    | Measurement 2   | 0.5                   | —    | 5.0                   |       |
| Delay time of excess current detection       | T <sub>OFF</sub>   | Measurement 2   | 0.5                   | —    | 5.0                   |       |
| Normal operating current consumption         | I <sub>OP</sub>    | Measurement 3   | —                     | 3.50 | 20                    | μA    |
| Power down current consumption               | I <sub>PDN</sub>   | Measurement 3   | —                     | 0.25 | 0.58                  |       |
| DO 'H' voltage                               | V <sub>DO(H)</sub> | Measurement 4   | V <sub>CC</sub> - 0.5 | —    | —                     | V     |
| DO 'L' voltage                               | V <sub>DO(L)</sub> | Measurement 4   | —                     | —    | V <sub>SS</sub> + 0.1 |       |
| CO 'H' voltage                               | V <sub>CO(H)</sub> | Measurement 5   | V <sub>CC</sub> - 0.5 | —    | —                     |       |

## ■ Measurement Circuits

### (1) Measurement 1

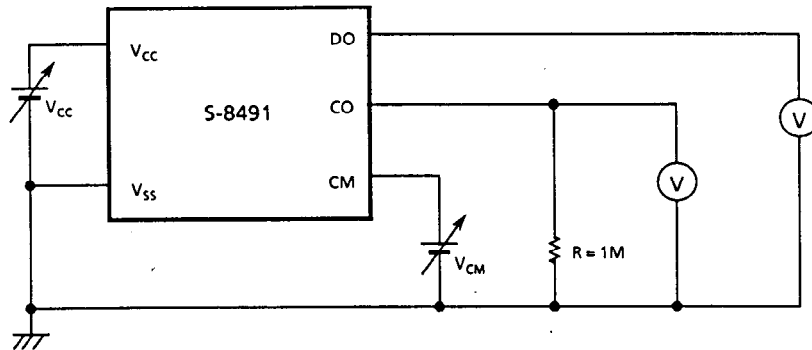


To measure excess charge detection voltage V<sub>CU</sub>, excess charge release voltage V<sub>CD</sub>, excess discharge detection voltage V<sub>DD</sub>, and excess discharge release voltage V<sub>DU</sub>, follow these steps:

- ① In the normal region with V<sub>CC</sub> = V<sub>CD</sub>, V<sub>CM</sub> = 0 V, excess charge detection voltage V<sub>CU</sub> is the voltage of V<sub>CC</sub> when CO goes low after gradually increasing V<sub>CC</sub>.
- ② In the excess charge region with V<sub>CC</sub> = V<sub>CU</sub> + 0.1 V, V<sub>CM</sub> = 0 V, excess charge release voltage V<sub>CD</sub> is the voltage of V<sub>CC</sub> when CO goes high after gradually increasing V<sub>CC</sub>.
- ③ In the normal region with V<sub>CC</sub> = V<sub>CD</sub>, V<sub>CM</sub> = 0 V, excess discharge detection voltage V<sub>DD</sub> is the voltage of V<sub>CC</sub> when DO goes low after gradually decreasing V<sub>CC</sub>.
- ④ In the excess discharge region with V<sub>CC</sub> = 2.0 V, V<sub>CM</sub> = 0 V, excess discharge release voltage V<sub>DU</sub> is the voltage of V<sub>CC</sub> when DO goes high after gradually increasing V<sub>CC</sub>.

Note: Rise and fall speeds of V<sub>CC</sub> are each specified at 150 V/sec or less.

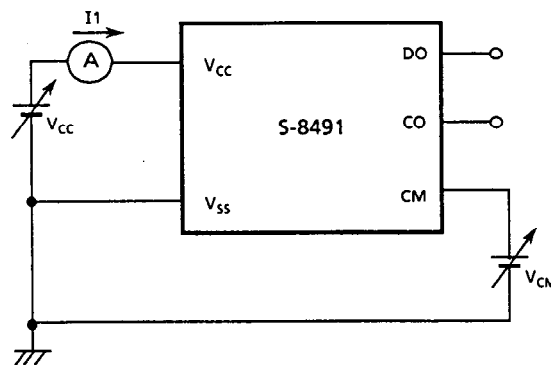
(2) Measurement 2



To measure excess charge detection time  $T_{CU}$ , excess discharge detection time  $T_{DD}$ , and excess current detection time  $T_{OFF}$ , follow these steps:

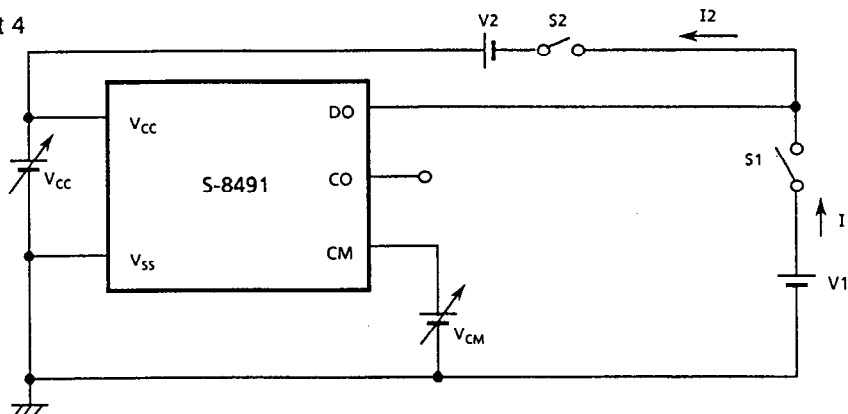
- ① In the normal region with  $V_{CC} = V_{CU} - 0.1$  V,  $V_{CM} = 0$  V, **excess charge detection time  $T_{CU}$**  is the time from when  $V_{CC}$  is  $V_{CU} + 0.1$  V to when CO goes low.
- ② In the normal region with  $V_{CC} = V_{DD} + 0.1$  V,  $V_{CM} = 0$  V, **excess discharge detection time  $T_{DD}$**  is the time from when  $V_{CC} = V_{DD} - 0.1$  V to when DO goes low.
- ③ In the normal region with  $V_{CC} = 3.5$  V,  $V_{CM} = 0$  V, **excess current detection time  $T_{OFF}$**  is the time from when  $V_{CM}$  is 3.5 V to when DO goes low.

(3) Measurement 3



- ① In the normal region with  $V_{CC} = 3.5$  V,  $V_{CM} = 0$  V, **normal operating current consumption  $I_{OPE}$**  is  $I_1$ .
- ② In the excess discharge region with  $V_{CC} = 2.0$  V,  $V_{CM} = 2.0$  V, **current consumption  $I_{PDN}$  in power-down mode** is  $I_1$ .

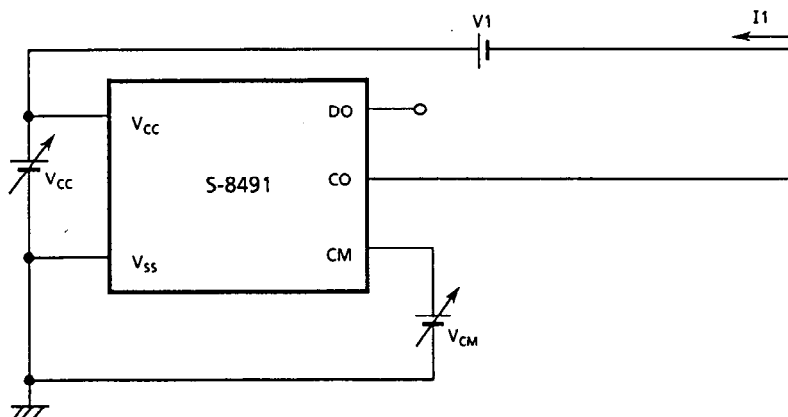
(4) Measurement 4



To measure DO 'H' voltage  $V_{DO(H)}$ , DO 'L' voltage  $V_{DO(L)}$ , follow these steps:

- ① In the normal region with  $V_{CC} = 3.5$  V,  $V_{CM} = 0$  V,  $S_1 = \text{open}$ ,  $S_2 = \text{close}$ ,  $V_2 = 0$  V, DO 'H' voltage  $V_{DO(H)}$  is the voltage of  $V_2$  when  $I_2$  is 10  $\mu$ A after gradually increasing  $V_2$ .
- ② In the excess current region with  $V_{CC} = 3.5$  V,  $V_{CM} = 3.5$  V,  $S_1 = \text{close}$ ,  $S_2 = \text{open}$ ,  $V_1 = 0$  V, DO 'L' voltage  $V_{DO(L)}$  is the voltage of  $V_1$  when  $I_1 = 10$   $\mu$ A after gradually increasing  $V_1$ .

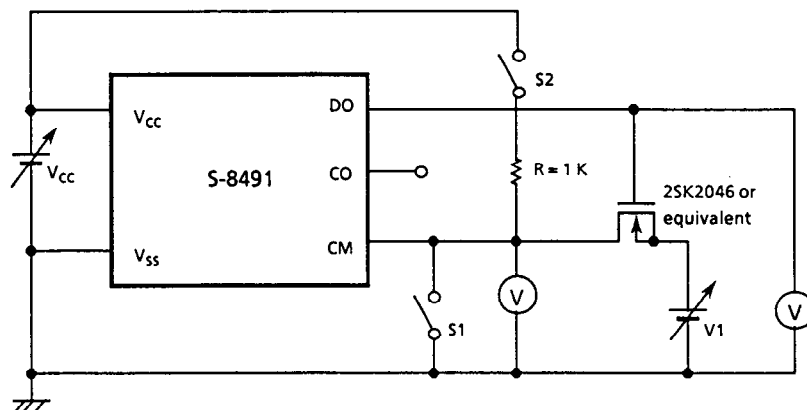
(5) Measurement 5



To measure CO 'H' voltage  $V_{CO(H)}$ , follow the step:

- ① In the normal region with  $V_{CC} = 3.5\text{ V}$ ,  $V_{CM} = 0\text{ V}$ ,  $V_1 = 0\text{ V}$ , CO 'H' voltage  $V_{CO(H)}$  is the voltage of  $V_1$  when  $I_1 = 10\text{ }\mu\text{A}$  after gradually increasing  $V_1$ .

(6) Measurement 6



To measure excess current detection voltage  $V_{IOV}$ , follow the step:

- ① In the normal region with  $V_{CC} = 3.5\text{ V}$ ,  $V_1 = 0\text{ V}$ ,  $S_1 = \text{close}$   $S_2 = \text{close}$ , **excess current detection voltage**  $V_{IOV}$  is the voltage of the CM pin when DO goes low after opening  $S_1$  and after gradually increasing  $V_1$ .

## ■ Operation

### Normal

This IC monitors both the voltage and the current of a battery connected between  $V_{CC}$  and  $V_{SS}$ , and controls charge and discharge. When the voltage of the battery is over  $V_{DD}$ , and below  $V_{CU}$ , and the voltage of the CM pin is below  $V_{IOV}$ , this IC turns ON the charge and discharge FETs. This is called the normal region.

### Excess Charge

In the normal region, when the voltage of the battery being charged exceeds  $V_{CU}$ , this IC stops charge by turning OFF the charge FET. This is called the excess charge region. When the battery voltage goes below  $V_{CD}$ , the state returns to the normal.

### Excess Discharge

In the normal region, when the voltage of the battery being discharged goes below  $V_{DD}$ , this IC stops discharge by turning OFF the discharge FET. Current consumption of the IC turns to  $I_{PDN}$  at this time. This is called the excess discharge region.

When a charger is connected in the excess discharge region and the battery voltage exceeds  $V_{DU}$ , the state returns to the normal.

### Excess Current

In the normal region, when the voltage of the CM pin exceeds  $V_{IOV}$  during discharge, this IC stops discharge by turning OFF the discharge FET. This is called excess current.

The state is returned to the normal by being more than 500M $\Omega$  resistance between EB+ and EB-, for example, by removing load.

### Delay Circuit

This IC is provided with a comparator for monitoring excess charge detection, excess discharge detection or excess current. Also, it has delay time from when the comparator detects the voltage to when the output voltage is inverted at DO and CO pins.

Delay occurs only during the following operations.

- (1) The "comparator" detects the excess charge detection voltage → Delay time → CO pin changes to the Hi-Z level.
- (2) The "comparator" detects the excess discharge detection voltage → Delay time → DO pin changes to the  $V_{SS}$  level.
- (3) The "comparator" detects the excess current detection voltage → Delay time → DO pin changes to the  $V_{SS}$  level.

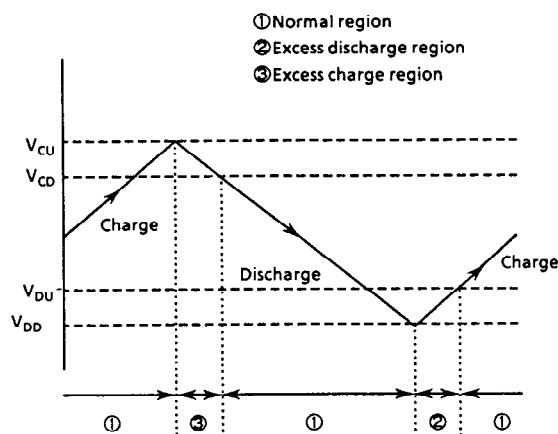


Figure 3

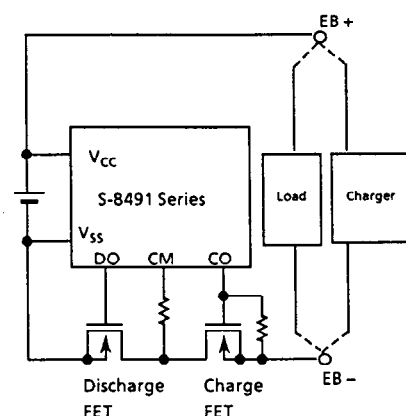


Figure 4

Table 5

| Region                                | DO pin        | CO pin           |
|---------------------------------------|---------------|------------------|
| Normal → Charge → Excess charge       | H             | H → Delay → Hi-z |
| Excess charge → Discharge → Normal    | H             | Hi-z → H         |
| Normal → Discharge → Excess discharge | H → Delay → L | H                |
| Excess discharge → Charge → Normal    | L → H         | H                |
| Excess charge → Excess current occurs | H → Delay → L | Hi-z             |
| Normal region → Excess current occurs | H → Delay → L | H → Hi-z         |
| Excess discharge → Load short         | L             | H                |

## ■ Operating Timing Charts

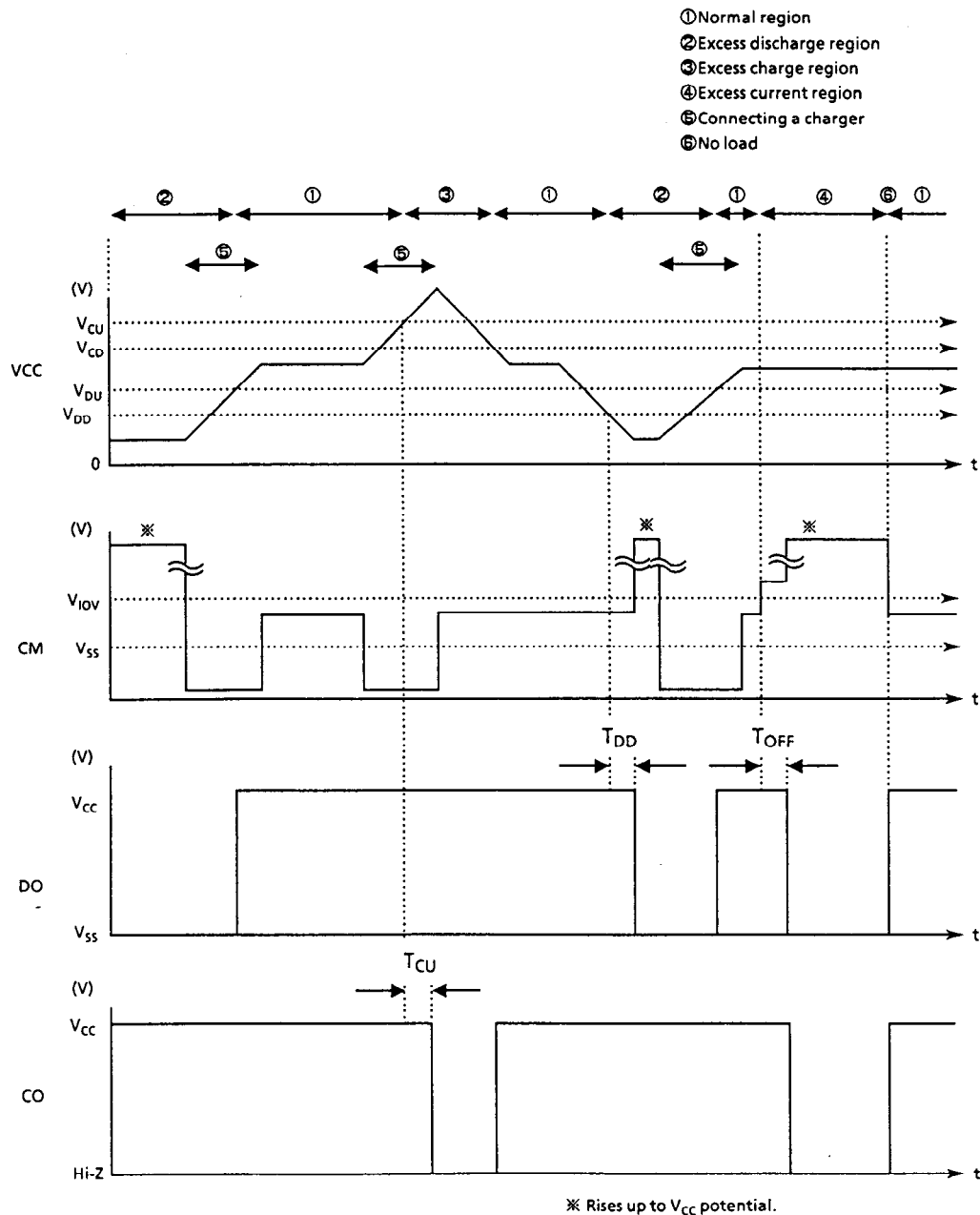


Figure 5

■ **Battery Protection IC Connection Diagram**

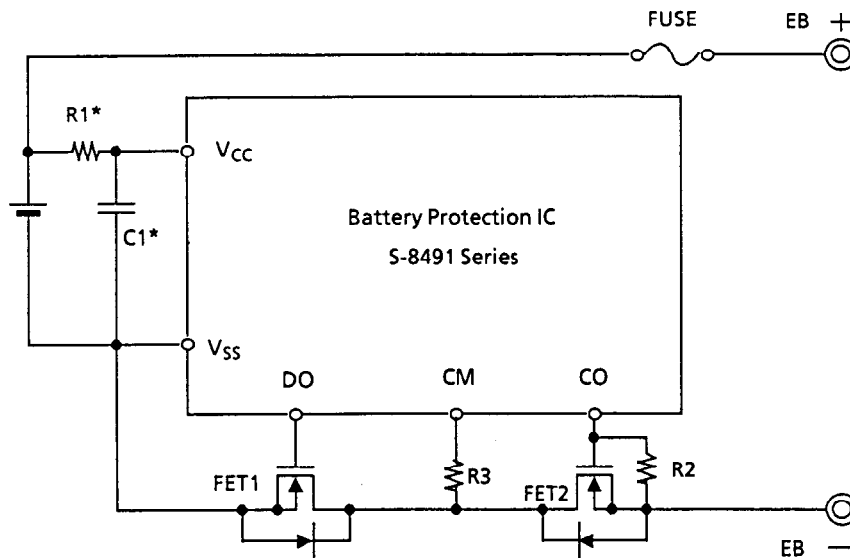


Figure 6

- Install an R1\* less than 1 K $\Omega$ .
- The R2 is a pull-down resistor which turns OFF FET2. The R2 also protects the IC when the charger is connected reversely. Use a resistor from 100 K $\Omega$  or more to 1 M $\Omega$  or less.
- The R3 protects the IC when the charger is connected reversely. Use a resistor from 1 K $\Omega$  or more to 10 K $\Omega$  or less.
- Install a C1\* more than 0.47  $\mu$ F.
- \* If they are needed for ESD ( Electric Static Discharge ) protection.
- \* The connection diagram explain typical applications of the products, and do not guarantee any massproduction design.

■ **Handling Precautions**

- In the excess discharge region, the voltage of the CM pin rises to the power supply voltage V<sub>CC</sub>. This forces the built-in comparator to stop. Unless the CM pin is down to the V<sub>CC</sub> level or less by connecting a charger, the excess discharge state can be retained.
- When initially connecting the battery to the IC, the state may go to the excess discharge state depending upon the characteristics of the capacitor or resistor attached to the CM pin. To return to the normal region, set the CM pin to the V<sub>SS</sub> level or less (connect a charger).
- Oscillation may occur depending upon the value of the capacitor or resistor attached to the CM or DO pin.  
 Select one from the following parts:  
 FET1 gate capacity: A capacitor of 5000 pF or less  
 Wiring resistance on the PCB between DO pin and FET1 gate: A resistor of 5  $\Omega$  or less  
 (Refer to Figure 4, Battery Protection IC Diagram )
- When the excess current generates, the battery voltage drops due to its internal impedance to stop discharge. If the voltage goes below the operating voltage of the IC (2.0 V), the excess discharge state may be retained even when the load is released. To return to the normal region, set the CM pin to the V<sub>SS</sub> or less (connect a charger).

■ Dimensions

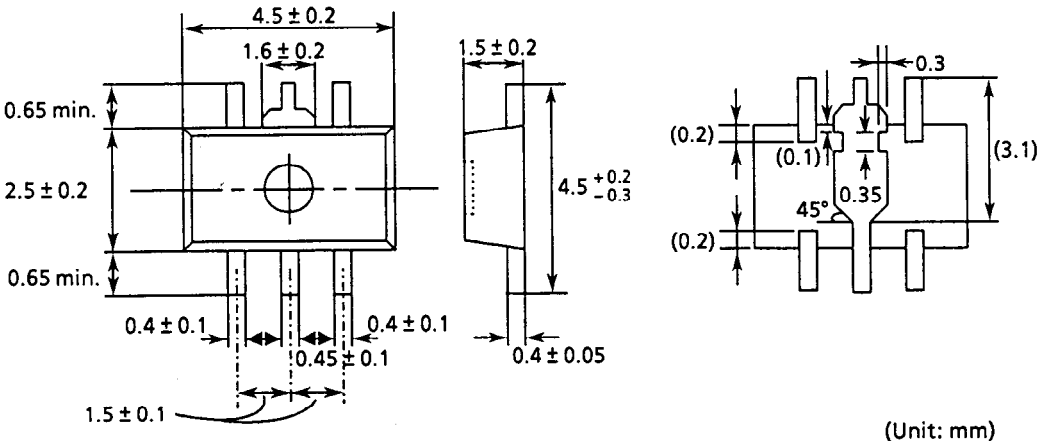


Figure 7

■ Markings

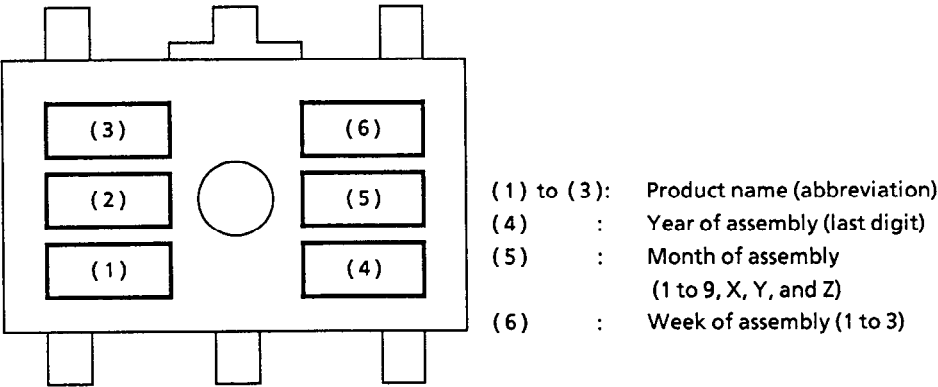


Figure 8

■ Taping

1. Tape Specifications

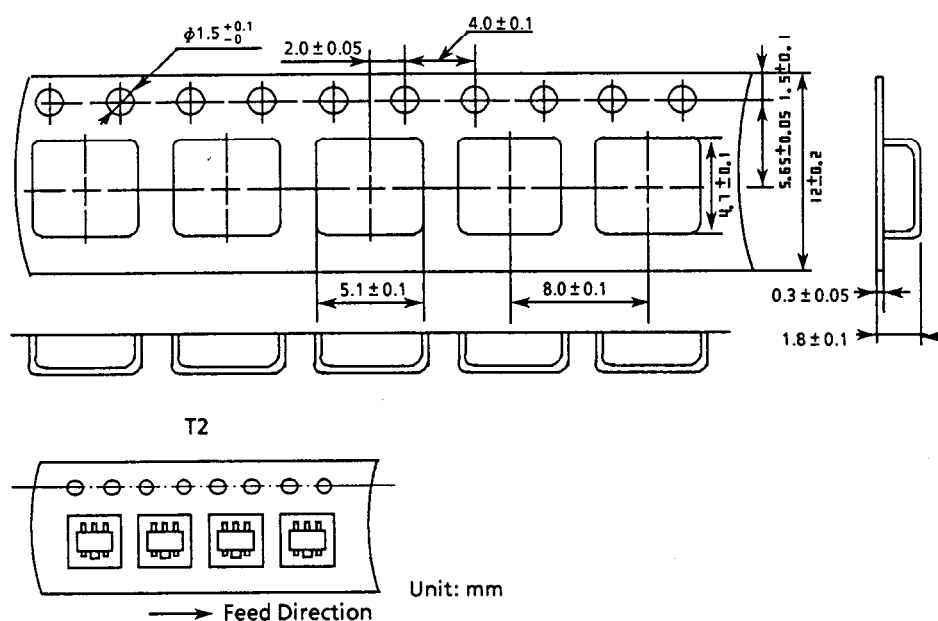


Figure 9

2. Reel Specifications

A reel holds 1000 ICs.

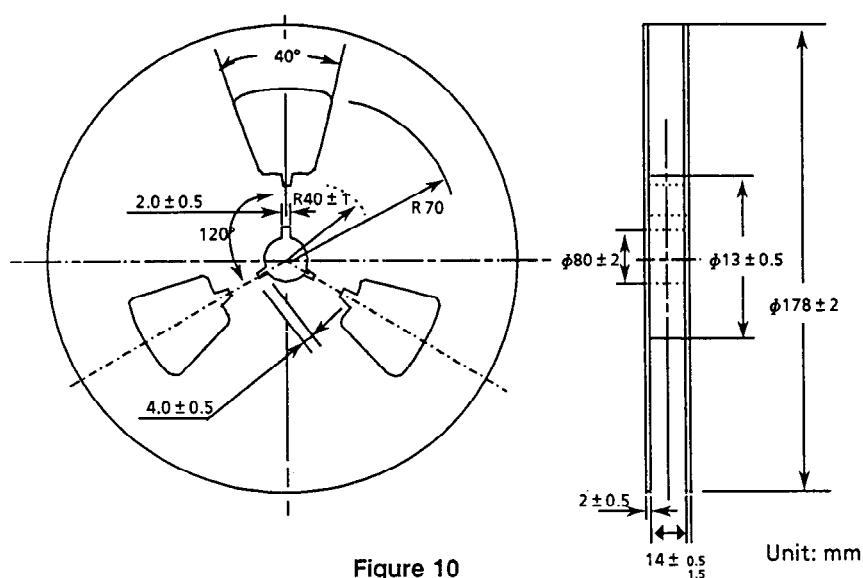
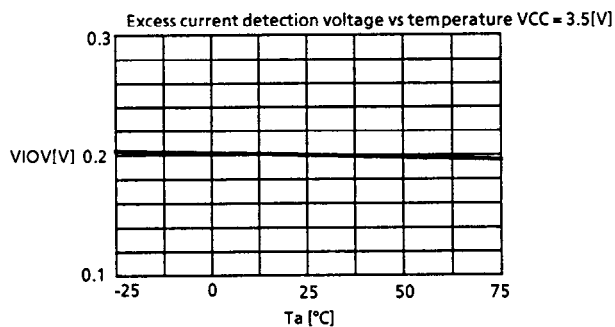
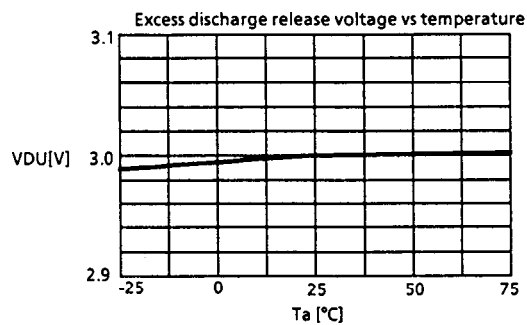
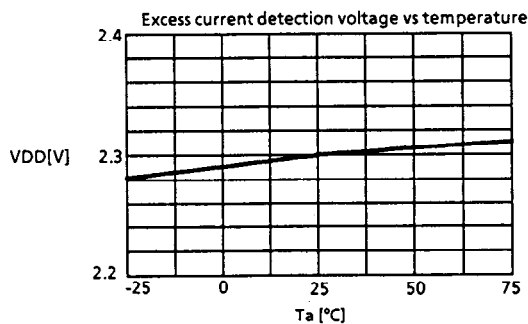
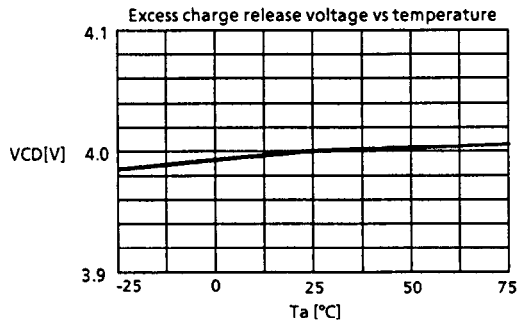
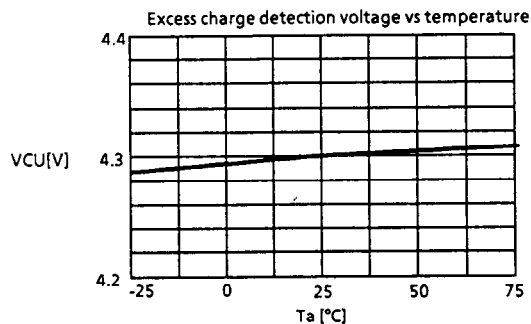


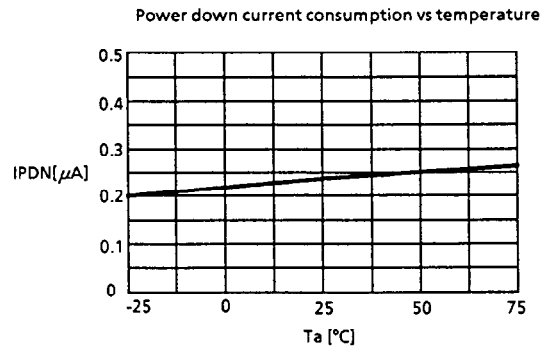
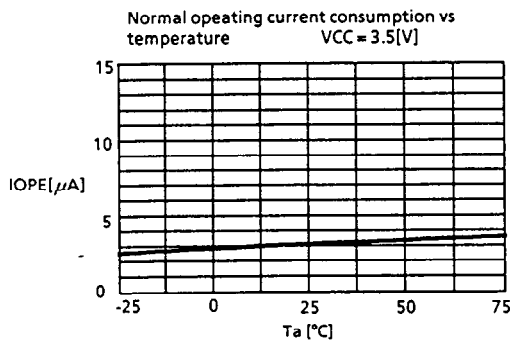
Figure 10

## ■ Characteristics

### 1. Temperature Characteristics of the Voltage Detector (Example: S8491AUP-DKA-T2)



### 2. Temperature characteristics of current consumption (Example: S8491AUP-DKA-T2)



3. Temperature Characteristics of Delay Time (Example: S8491AUP-DKA-T2)

