BATTRY PROTECTION IC FOR 1-SERIAL TO 4-SERIAL (SECONDARY PROTECTION)

S-8244 Series

The S-8244 Series is used for secondary protection of lithium-ion batteries with from one to four cells, and incorporates a high-precision voltage detector circuit and a delay circuit. Short-circuits between cells accommodate series connection of one to four cells.

■ Features

- Internal high-precision voltage detector circuit

  1) Overcharge detection voltage range:

  3.70 to 4.50 V: Accuracy of ± 25 mV (at +25°C)
  (at a 5 mV/step) Accuracy of ± 50 mV (at -40 to +85°C)

  2) Hysteresis: 5 optional models available and selectable:

  0.38±0.1 V, 0.25±0.07 V, 0.13±0.04 V, 0.045±0.02 V, None

- High withstand voltage device absolute maximum rating: 26 V
- Wide operating voltage range: 3.6 V to 24 V (refers to the range in which the delay circuit can operate normally after overvoltage is detected)
- Delay time during detection: Can be set by an external capacitor.
- Low current consumption

  At 3.5 V for each cell: 3.0 μA max. (+25°C)

  At 2.3 V for each cell: 2.4 μA max. (+25°C)

- Output logic and form - 4 types:

  CMOS output active “H”

  CMOS output active “L”

  Pch open drain output active “L”

  Nch open drain output active “H”

  (only CMOS output for 0.045 V hysteresis models)

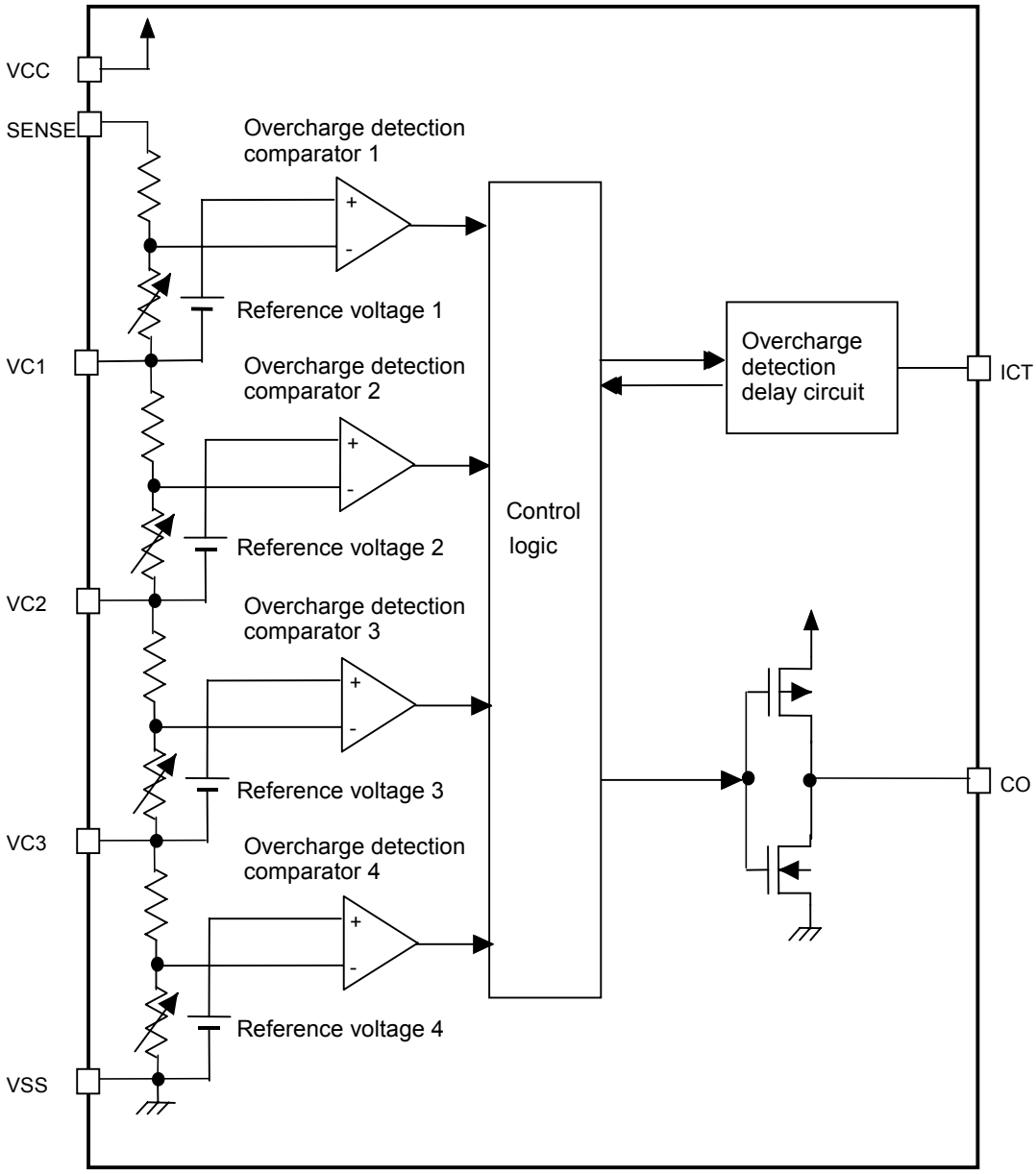
■ Applications

- Lithium ion rechargeable battery packs (secondary protection)

■ Package

- 8-Pin MSOP (Package drawing code: FN008-A)

■ Block Diagram

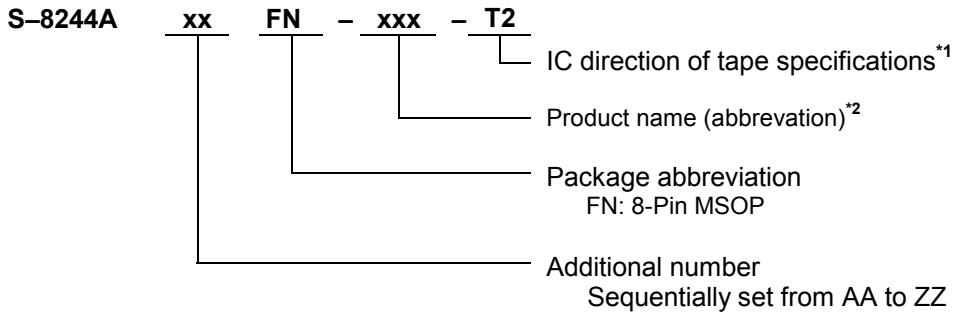


Note In the case of Nch open-drain output, only the Nch transistor will be connected to the CO pin. In the case of Pch open-drain output, only the Pch transistor will be connected to the CO pin.

Figure 1

■ Selection Guide

1. Product Name



***1.** Refer to the taping drawing.
***2.** Refer to the product name list.

2. Product Name List

Table 1

Model No./Item	Overcharge detection voltage V_{CU}	Overcharge hysteresis voltage V_{CD}	Output form
S-8244AAAFN-CEA-T2	4.45 ± 0.025 V	0.38 ± 0.1 V	CMOS output active “H”
S-8244AABFN-CEB-T2	4.2 ± 0.025 V	0 V	Nch open drain active “H”
S-8244AACFN-CEC-T2	4.115 ± 0.025 V	0.13 ± 0.04 V	CMOS output active “H”
S-8244AADFN-CED-T2	4.2 ± 0.025 V	0 V	Pch open drain active “L”
S-8244AAEFN-CEE-T2	4.225 ± 0.025 V	0 V	Nch open drain active “H”
S-8244AAFFN-CEF-T2	4.35 ± 0.025 V	0.045 ± 0.02 V	CMOS output active “H”
S-8244AAGFN-CEG-T2	4.45 ± 0.025 V	0.045 ± 0.02 V	CMOS output active “H”
S-8244AAHFN-CEH-T2	4.30 ± 0.025 V	0.25 ± 0.07 V	CMOS output active “H”

Remark If a product with the required detection voltage does not appear in the above list, contact our sales office.

■ Pin Assignment

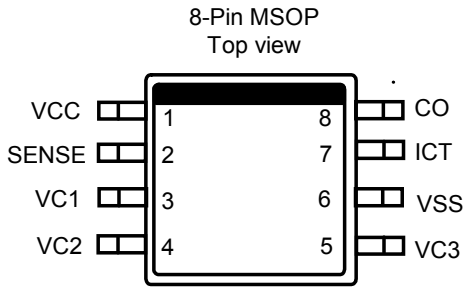


Figure 2

Table 2

Pin No.	Symbol	Description
1	VCC	Positive power input pin
2	SENSE	Positive voltage connection pin of Battery 1
3	VC1	Negative voltage connection pin of Battery 1; Positive voltage connection pin of Battery 2
4	VC2	Negative voltage connection pin of Battery 2; Positive voltage connection pin of Battery 3
5	VC3	Negative voltage connection pin of Battery 3; Positive voltage connection pin of Battery 4
6	VSS	Negative power input pin; Negative voltage connection pin of Battery 4
7	ICT	Capacitor connection pin for overcharge detection delay
8	CO	FET gate connection pin for charge control

■ Absolute Maximum Ratings

Table 3 (Ta = 25°C unless otherwise specified)

Item	Symbol	Applicable pin	Rating	Unit
Input voltage between VCC and VSS	V_{DS}	VCC	V_{SS}–0.3 to V_{SS}+26	V
Delay capacitor connection pin voltage	V_{ICT}	ICT	V_{SS} –0.3 to V_{CC} +0.3	V
Input pin voltage	V_{IN}	SENSE, VC1, VC2, VC3	V_{SS} –0.3 to V_{CC} +0.3	V
CO output pin voltage	V_{CO}	CO	V_{SS} –0.3 to V_{CC} +0.3 (CMOS output)	V
			V_{SS} –0.3 to 26 (Nch open drain output)	
			V_{CC} –26 to V_{CC} +0.3 (Pch open drain output)	
Power dissipation	P_D	—	300	mW
Operating temperature range	T_{opr}	—	–40 to +85	°C
Storing temperature range	T_{stg}	—	–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.

■ Electrical Characteristics

Table 4 (Ta = 25°C unless otherwise specified)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit	Measure-ment conditions	Measure-ment circuit
DETECTION VOLTAGE								
Overcharge detection voltage 1 *1	V_{CU1}	3.7 to 4.5 V Adjustment	V_{CU1} −0.025	V_{CU1}	V_{CU1} +0.025	V	1	1
Overcharge detection voltage 2 *1	V_{CU2}	3.7 to 4.5 V Adjustment	V_{CU2} −0.025	V_{CU2}	V_{CU2} +0.025	V	2	1
Overcharge detection voltage 3 *1	V_{CU3}	3.7 to 4.5 V Adjustment	V_{CU3} −0.025	V_{CU3}	V_{CU3} +0.025	V	3	1
Overcharge detection voltage 4 *1	V_{CU4}	3.7 to 4.5 V Adjustment	V_{CU4} −0.025	V_{CU4}	V_{CU4} +0.025	V	4	1
Overcharge hysteresis voltage 1 *2	V_{CD1}	—	0.28	0.38	0.48	V	1	1
Overcharge hysteresis voltage 2 *2	V_{CD2}	—	0.28	0.38	0.48	V	2	1
Overcharge hysteresis voltage 3 *2	V_{CD3}	—	0.28	0.38	0.48	V	3	1
Overcharge hysteresis voltage 4 *2	V_{CD4}	—	0.28	0.38	0.48	V	4	1
Detection voltage temperature coefficient *3	T_{COE}	Ta=−40 to 85°C	−0.4	0.0	+0.4	mV/°C	—	—
DELAY TIME								
Overcharge detection delay time	t_{CU}	C=0.1 µF	1.0	1.5	2.0	s	5	2
OPERATING VOLTAGE								
Operating voltage between VCC and VSS *4	V_{DSOP}	—	3.6	—	24	V	—	—
CURRENT CONSUMPTION								
Current consumption during normal operation	I_{OPE}	V1=V2=V3=V4=3.5V	—	1.5	3.0	µA	6	3
Current consumption at power down	I_{PDN}	V1=V2=V3=V4=2.3V	—	1.2	2.4	µA	6	3
VC1 sink current	I_{VC1}	V1=V2=V3=V4=3.5V	−0.3	—	0.3	µA	6	3
VC2 sink current	I_{VC2}	V1=V2=V3=V4=3.5V	−0.3	—	0.3	µA	6	3
VC3 sink current	$I_{VC}3$	V1=V2=V3=V4=3.5V	−0.3	—	0.3	µA	6	3
OUTPUT VOLTAGE *5								
CO “H” voltage	$V_{CO(H)}$	at I_{OUT} = 10 µA	V_{CC} −0.05	—	—	V	7	4
CO “L” voltage	$V_{CO(L)}$	at I_{OUT} = 10 µA	—	—	V_{SS} +0.05	V	7	4

*1. ±50 mV when Ta = −40 to +85°C.
*2. 0.25±0.07 V, 0.13±0.04 V, 0.045±0.02 V except for 0.38 V hysteresis models.
*3. Overcharge detection voltage or overcharge hysteresis voltage.
*4. Operating voltage indicates that the delay circuit operates normally after an overcharge is detected.
*5. Output logic and CMOS or open drain output can be selected.

■ Measurement Circuits

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

Conditions:
- Set switches 1 and 2 to OFF for CMOS output models.
- Set switch 1 to ON and switch 2 to OFF for Nch open drain models.
- Set switch 1 to OFF and switch 2 to ON for Pch open drain models.

Definitions:
- Set V1, V2, V3 and V4 to 3.5 V and gradually increase V1:
  Overcharge detection voltage 1 (V_{CU1}) is defined as V1 voltage when CO is turned to “H” (for CMOS output active “H” or Nch open drain) or “L” (for CMOS output active “L” or Pch open drain).
- Next, gradually decrease V1:
  Overcharge hysteresis voltage V_{CD1} is defined as a difference between V_{CU1} and V1 when CO is turned to “L” (for CMOS output active “H” or Nch open drain) or “H” (for CMOS output active “L” or Pch open drain).

(2) **Measurement Condition 2, Measurement Circuit 1**

Conditions:
- Set switches 1 and 2 to OFF for CMOS output models.
- Set switch 1 to ON and switch 2 to OFF for Nch open drain models.
- Set switch 1 to OFF and switch 2 to ON for Pch open drain models.

Definitions:
- Set V1, V2, V3 and V4 to 3.5 V and gradually increase V2.
  Overcharge detection voltage 2 (V_{CU2}) is defined as V2 voltage when CO is turned to “H” (for CMOS output active “H” or Nch open drain) or “L” (for CMOS output active “L” or Pch open drain).
- Next, gradually decrease V2.
  Overcharge hysteresis voltage V_{CD2} is defined as a difference between V_{CU2} and V2 when CO is turned to “L” (for CMOS output active “H” or Nch open drain) or “H” (for CMOS output active “L” or Pch open drain).

(3) **Measurement Condition 3, Measurement Circuit 1**

Conditions:
- Set switches 1 and 2 to OFF for CMOS output models.
- Set switch 1 to ON and switch 2 to OFF for Nch open drain models.
- Set switch 1 to OFF and switch 2 to ON for Pch open drain models.

Definitions:
- Set V1, V2, V3 and V4 to 3.5 V and gradually increase V3.
  Overcharge detection voltage 3 (V_{CU3}) is defined as V3 voltage when CO is turned to “H” (for CMOS output active “H” or Nch open drain) or “L” (for CMOS output active “L” or Pch open drain).
- Next gradually decrease V3.
  Overcharge hysteresis voltage V_{CD3} is defined as a difference between V_{CU3} and V3 when CO is turned to “L” (for CMOS output active “H” or Nch open drain) or “H” (for CMOS output active “L” or Pch open drain).

(4) **Measurement Condition 4, Measurement Circuit 1**

Conditions:
- Set switches 1 and 2 to OFF for CMOS output models.
- Set switch 1 to ON and switch 2 to OFF for Nch open drain models.
- Set switch 1 to OFF and switch 2 to ON for Pch open drain models.

Definitions:

- Set V1, V2, V3 and V4 to 3.5 V and gradually increase V4.
  Overcharge detection voltage 4 (V_{CU4}) is defined as V4 voltage when CO is turned to "H" (for CMOS output active "H" or Nch open drain) or "L" (for CMOS output active "L" or Pch open drain).
- Next, gradually decrease V4.
  Overcharge hysteresis voltage V_{CD4} is defined as a difference between V_{CU4} and V4 when CO is turned to "L" (for CMOS output active "H" or Nch open drain) or "H" (for CMOS output active "L" or Pch open drain).

(5) **Measurement Condition 5, Measurement Circuit 2**

Conditions:

- Set switches 1 and 2 to OFF for CMOS output models.
- Set switch 1 to ON and switch 2 to OFF for Nch open drain models.
- Set switch 1 to OFF and switch 2 to ON for Pch open drain models.

Definition:

- Set V1, V2, V3 and V4 to 3.5 V and momentarily rise V1 to 4.7 V within10 μs.
  Overcharge detection delay time (t_{CU}) is the period from when V1 goes 4.7 V to when CO is turned to "H" (for CMOS output active "H" or Nch open drain) or "L" (for CMOS output active "L" or Pch open drain).

(6) **Measurement Condition 6, Measurement Circuit 3**

Conditions:

- Set V1, V2, V3 and V4 to 2.3 V.
- Measure current consumption (I1).

Definition:

- The current consumption (I1) is defined as current consumption at power down (I_{PDN}).

Conditions:

- Set V1, V2, V3 and V4 to 3.5 V.
- Measure current consumption I1, I2, I3, and I4.

Definition:

- The current consumption (I1) is defined as current consumption during normal operation (IOPE), the current consumption (I2) as VC1 sink current (I_{VC1}), the current consumption (I3) as V_{C2} sink current(I_{VC2}), and the current consumption (I4) as V_{C3} sink current (I_{VC3}), respectively.

(7) **Measurement Condition 7, Measurement Circuit 4**

Conditions:

- Set switch 1 to ON and switch 2 to OFF for CMOS output active "H" or Nch open drain models.
- Set switch 1 to OFF and switch 2 to ON for Pch open drain models.

Definitions:

- Set V1, V2, V3 and V4 to 3.5 V and gradually increase V5 from 0V (for CMOS output active "H" or Nch open drain models).
  V5 voltage is defined as $V_{CO\,(H)}$ when I1 (= 10 μA) flows.
- Set V1, V2, V3 and V4 to 3.5 V and gradually increase V6 from 0 V (for CMOS output active "L" or Pch open drain models).
  V6 voltage is defined as $V_{CO\,(L)}$ when I2 (= 10 μA) flows.

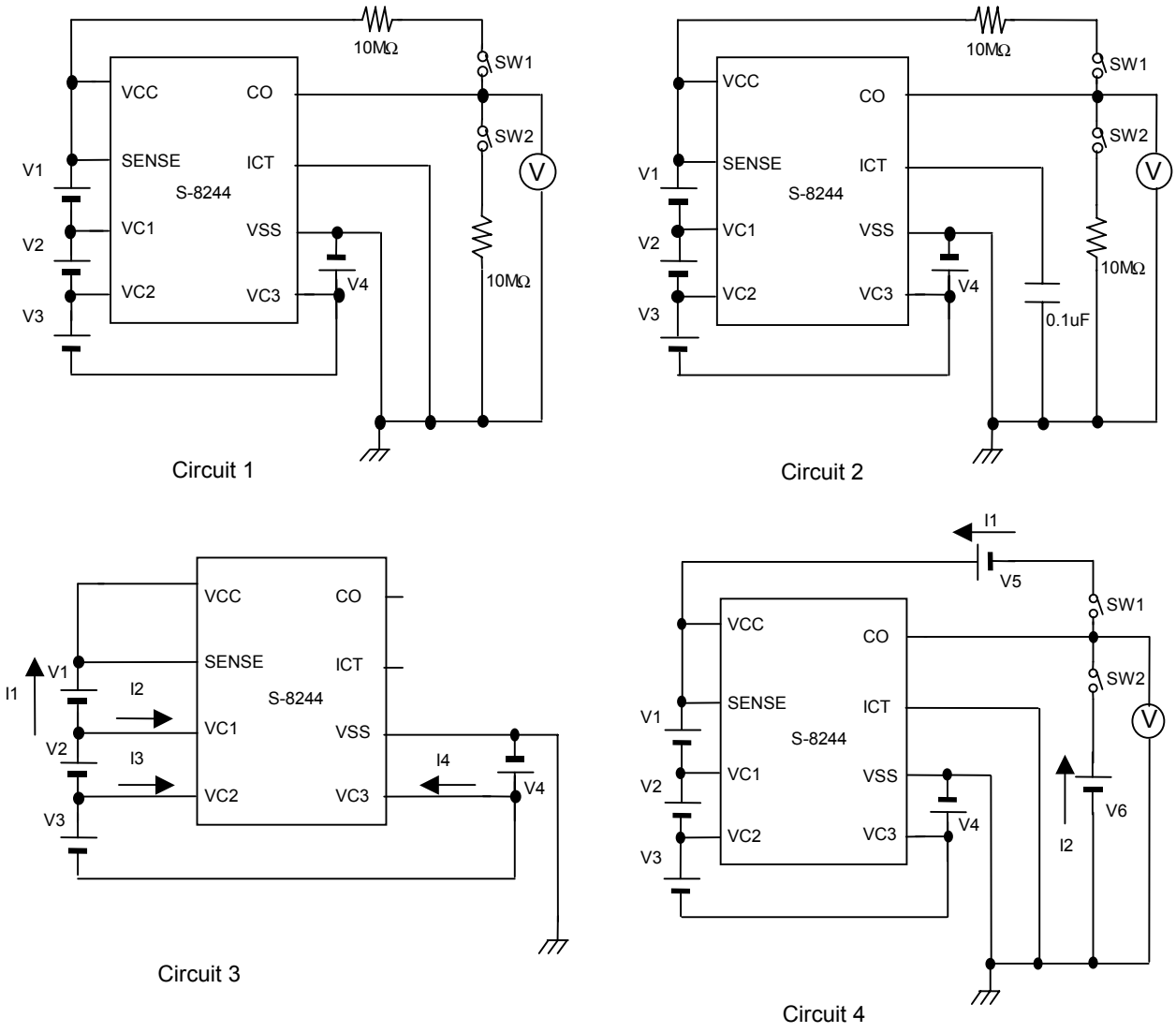

10MΩ
SW1
SW2
VCC
CO
SENSE
ICT
S-8244
V1
V2
V3
VC1
VC2
VSS
VC3
V4
10MΩ
V
Circuit 1
10MΩ
SW1
SW2
VCC
CO
SENSE
ICT
S-8244
V1
V2
V3
VC1
VC2
VSS
VC3
V4
10MΩ
0.1uF
V
Circuit 2
VCC
CO
SENSE
ICT
S-8244
V1
V2
V3
VC1
VC2
VSS
VC3
V4
I1
I2
I3
I4
Circuit 3
I1
V5
SW1
SW2
VCC
CO
SENSE
ICT
S-8244
V1
V2
V3
VC1
VC2
VSS
VC3
V4
V6
I2
V
Circuit 4

Figure 3

■ Description of Operation

Overcharge Detection

CO is turned to "H" (for CMOS output active "H" or Nch open drain models) or "L" (for CMOS output active "L" or Pch open drain models) when the voltage of one of the batteries exceeds the overcharge detection voltage (V_{CU}) during charging under normal conditions beyond the overcharge detection delay time (t_{CU}). This state is called "overcharge." Attaching FET to the CO pin provides charge control and a second protection. At that time, the overcharge state is maintained until the voltage of all batteries decreases from the overcharge detection voltage (V_{CU}) by the equivalent to the overcharge hysteresis voltage (V_{CD}).

Delay Circuit

The delay circuit rapidly charges the capacitor connected to the delay capacitor connection pin up to a specified voltage when the voltage of one of the batteries exceeds the overcharge detection voltage (V_{CU}). Then, the delay circuit gradually discharges the capacitor at 100 nA and inverts the CO output when the voltage at the delay capacitor connection pin goes below a specified level. Overcharge detection delay time (t_{CU}) varies depending upon the external capacitor.

Each delay time is calculated using the following equation (Ta= –40 to +85°C).

	Min.	Typ.	Max.		
t_{CU}[s] = Delay Coefficient	(10,	15,	20)	×	C_{ICT} [μF]

Because the delay capacitor is rapidly charged, the smaller the capacitance, the larger the difference between the maximum voltage and the specified value of delay capacitor pin (ICT pin). This will cause a deviation between the calculated delay time and the resultant delay time. Also, delay time is internally set in this IC to prevent the CO output from inverting until the charge to delay capacitor pin is reached to the specified voltage. If large capacitance is used, output may be enabled without delay time because charge is disabled within the internal delay time.
Please note that the maximum capacitance connected to the delay capacitor pin (ICT pin) is 1 μF.

■ Operation Timing Chart

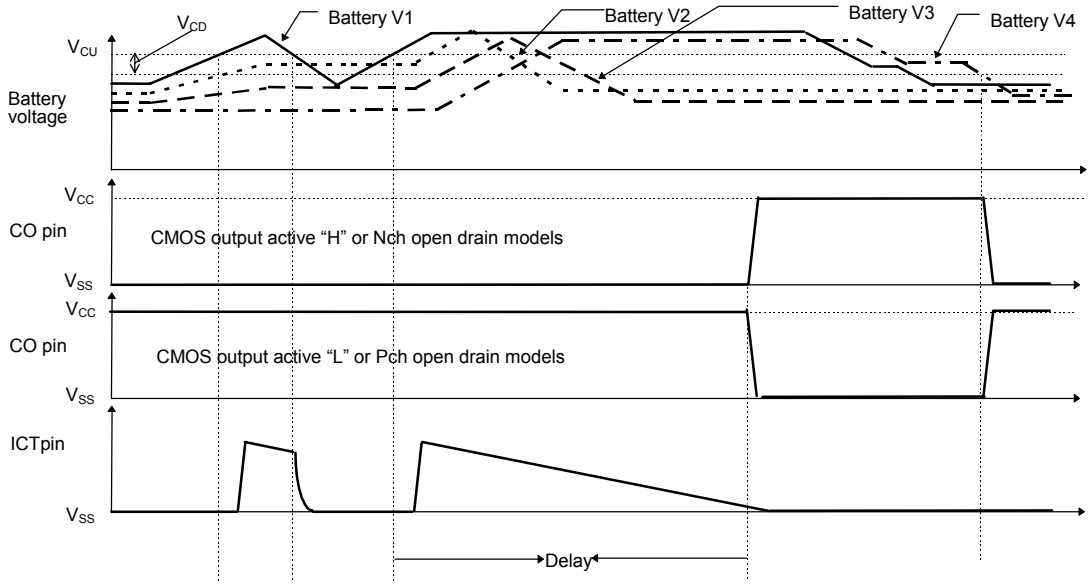


Figure 4

■ Battery Protection IC Connection Example 1

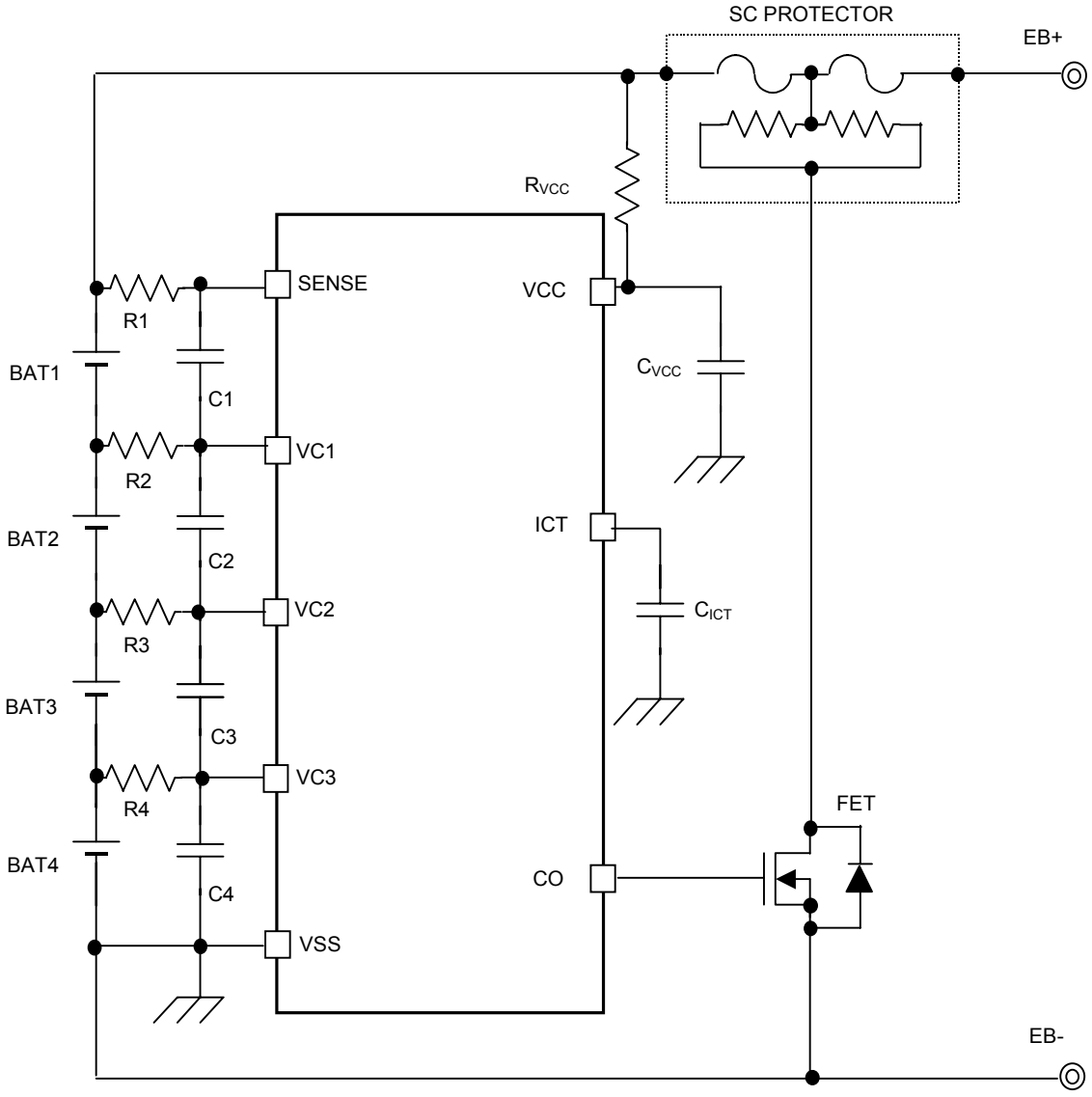


Figure 5

Table 5 Recommended value for External Parts 1

Symbol	Min.	Recommended Value	Max.	Unit
R1 to R4	0	1 k	10 k	Ω
C1 to C4	0	0.1	1	μF
R_{VCC}	0	100	1 k	Ω
C_{VCC}	0	0.1	1	μF
C_{ICT}	0	0.1	1	μF

Caution The standard circuit above does not guarantee proper operation. Evaluation in the actual application is needed to determine the correct constants.

For SC PROTECTOR, contact

Sony Chemicals Corporation
SIP Division
1-11-2 Osaki, Shinagawa-ku, Tokyo, 141-0032 Japan
TEL: +81-3-5435-3943 FAX: +81-3-5435-3072

■ Battery Protection IC Connection Example 2

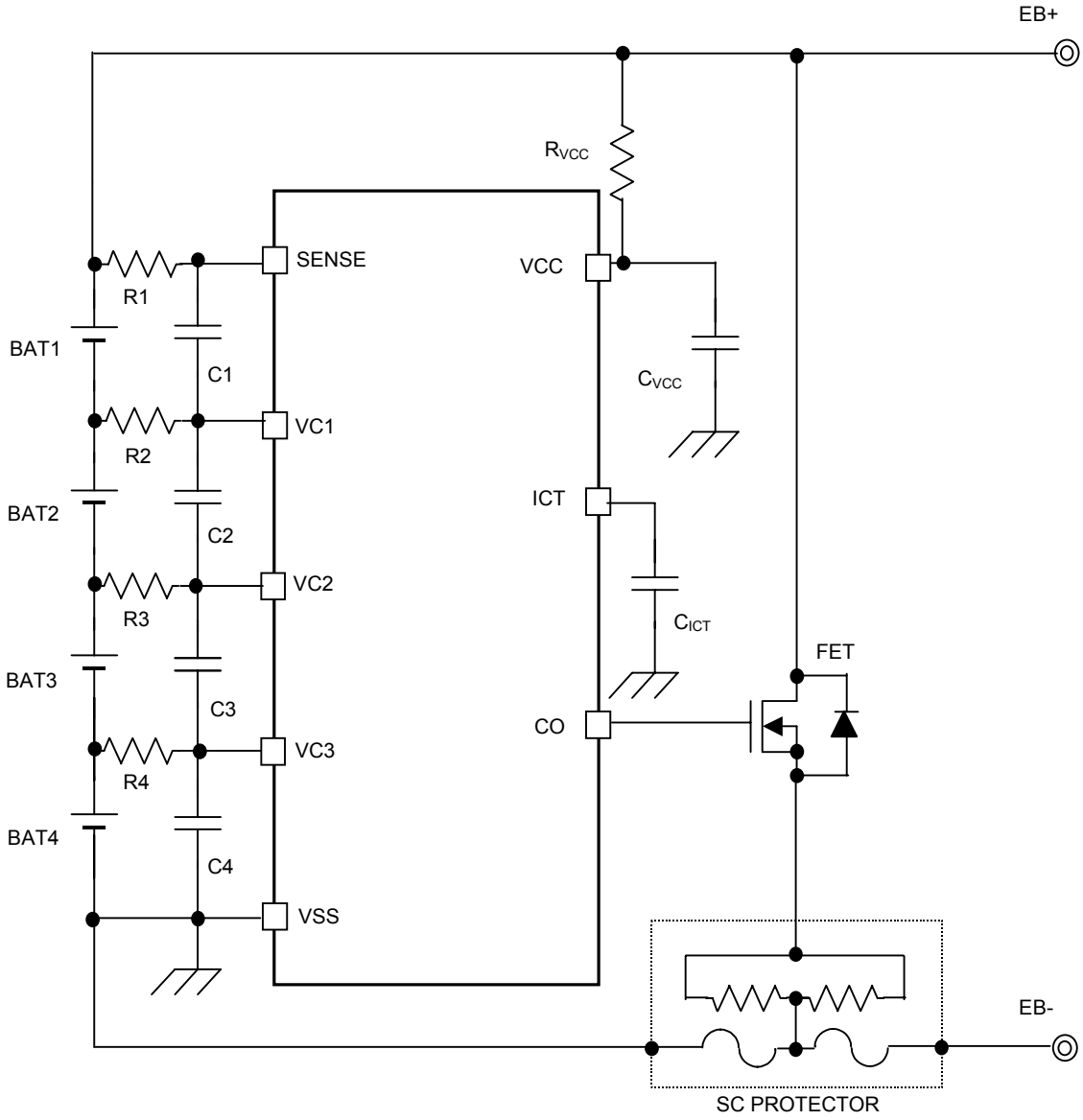


Figure 6

Table 6 Recommended Value for External Parts 2

	Min.	Recommended Value	Max.	Unit
R1 to R4	0	1 k	10 k	Ω
C1 to C4	0	0.1	1	μF
R_{VCC}	0	100	1 k	Ω
C_{VCC}	0	0.1	1	μF
C_{ICT}	0	0.1	1	μF

Caution The standard circuit above does not guarantee proper operation. Evaluation in the actual application is needed to determine the correct constants.

■ Battery Protection IC Connection Example 3 (for three cells)

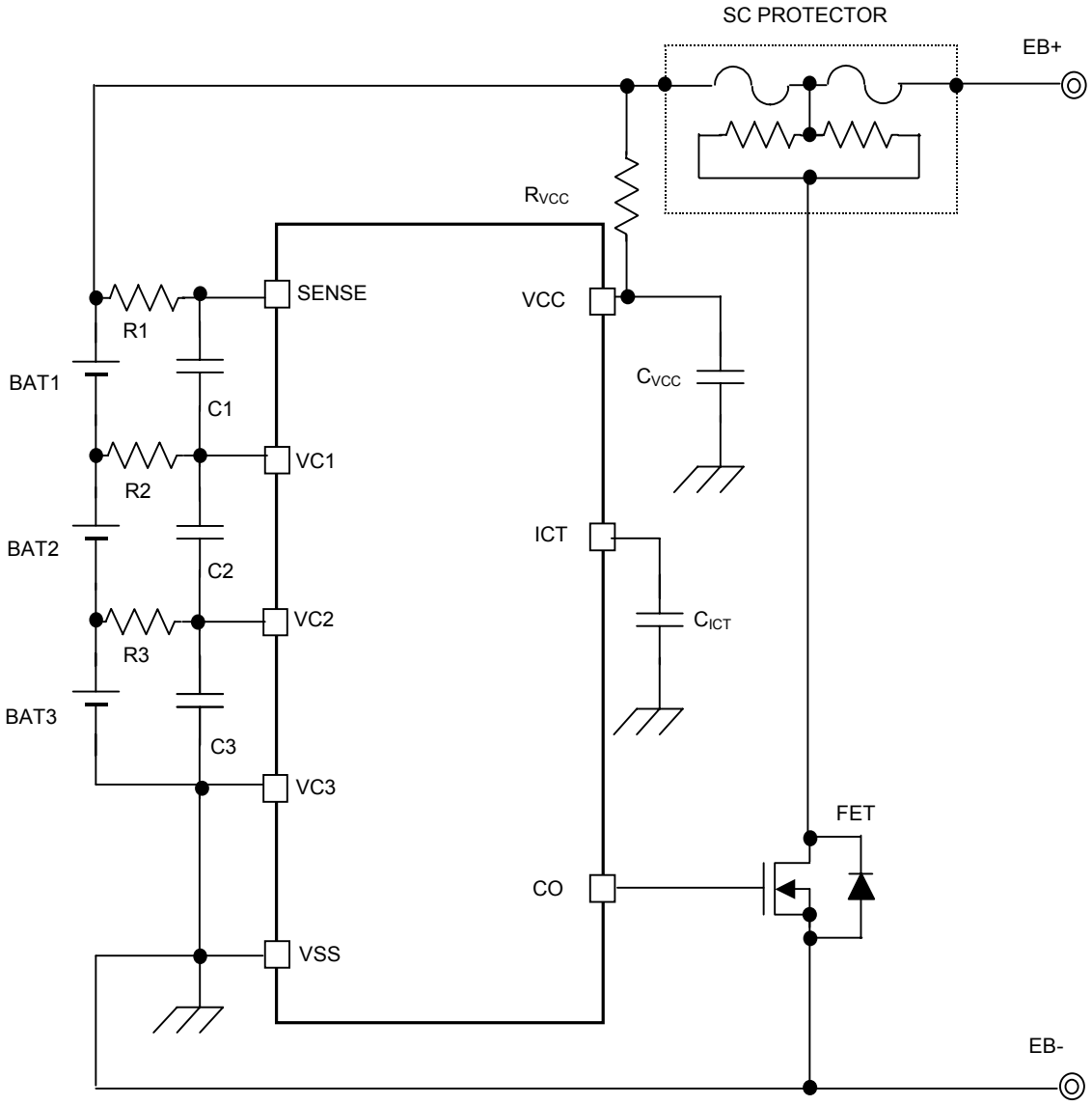


Figure 7

Table 7 Recommended Value for External Parts 3

Symbol	Min.	Recommended Value	Max.	Unit
R1 to R3	0	1 k	10 k	Ω
C1 to C3	0	0.1	1	μF
R_{VCC}	0	100	1 k	Ω
C_{VCC}	0	0.1	1	μF
C_{ICT}	0	0.1	1	μF

Caution The standard circuit above does not guarantee proper operation. Evaluation in the actual application is needed to determine the correct constants.

■ Battery Protection IC Connection Example 4 (for two cells)

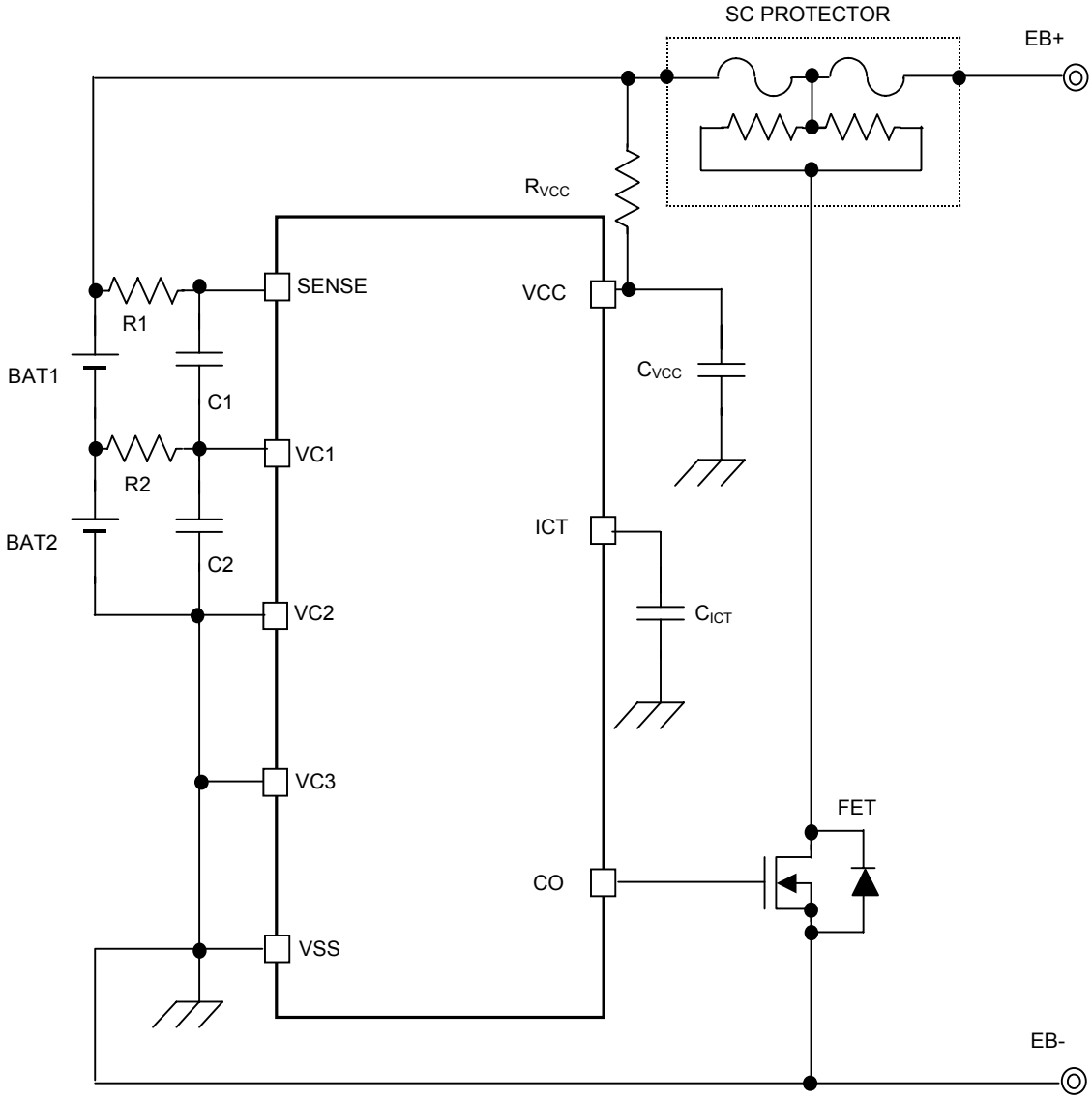


Figure 8

Table 8 Recommended Value for External Parts 4

Symbol	Min.	Recommended Value	Max.	Unit
R1, R2	0	1 k	10 k	Ω
C1, C2	0	0.1	1	μF
R_{VCC}	0	100	1 k	Ω
C_{VCC}	0	0.1	1	μF
C_{ICT}	0	0.1	1	μF

Caution The standard circuit above does not guarantee proper operation. Evaluation in the actual application is needed to determine the correct constants.

■ Battery Protection IC Connection Example 5 (for one cell)

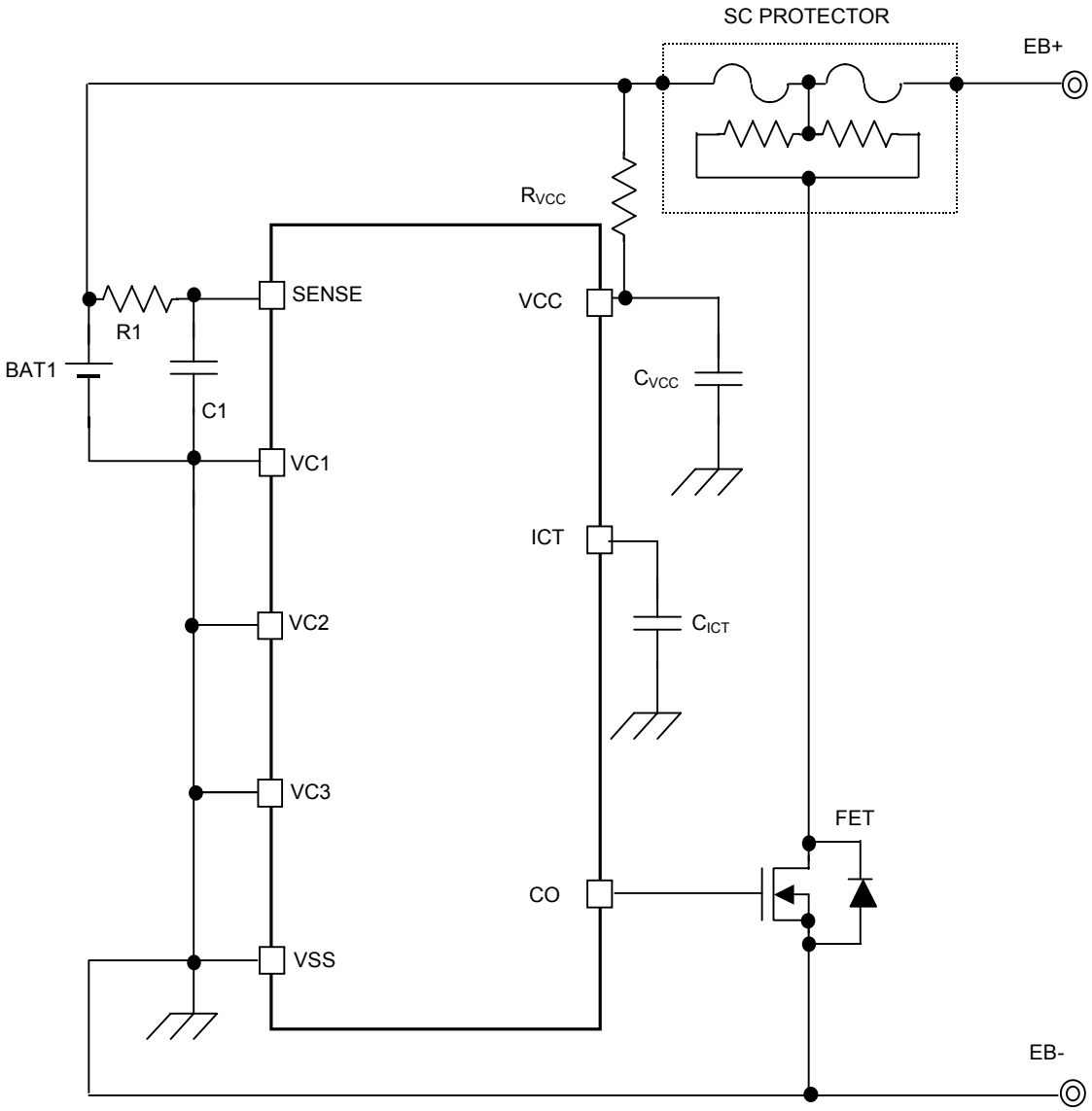


Figure 9

Table 9 Recommended Value for External Parts 5

Symbol	Min.	Recommended Value	Max.	Unit
R1	0	1 k	10 k	Ω
C1	0	0.1	1	μF
R_{VCC}	0	100	1 k	Ω
C_{VCC}	0	0.1	1	μF
C_{ICT}	0	0.1	1	μF

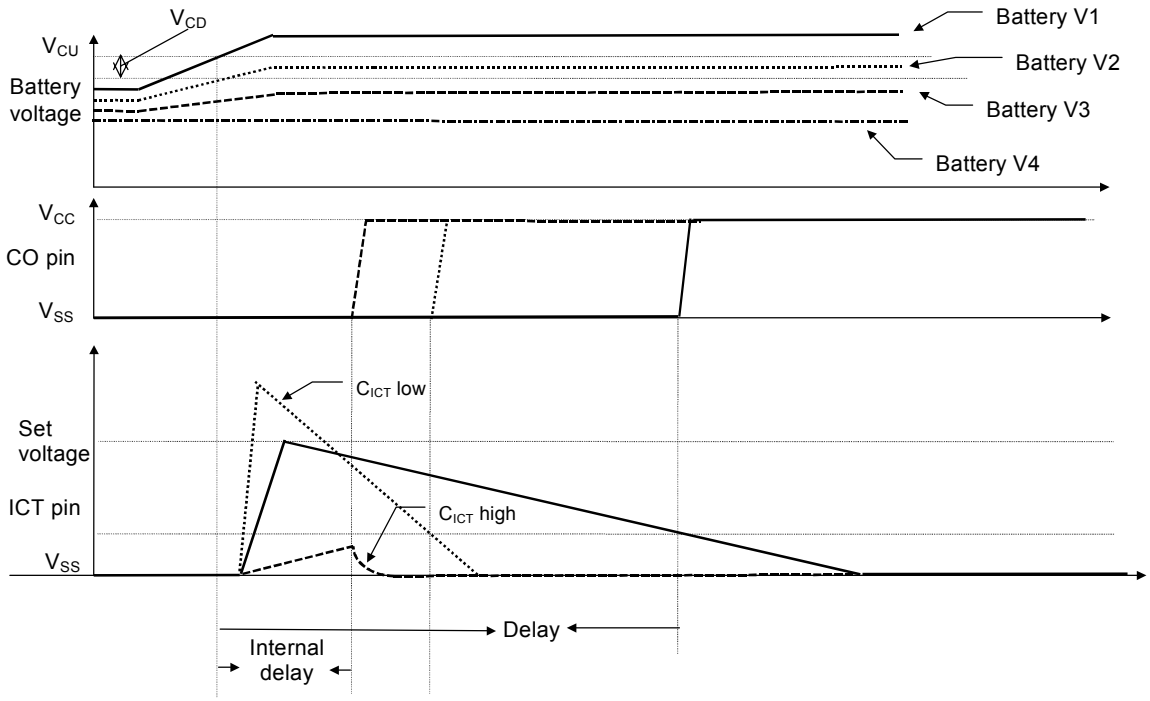
Caution The standard circuit above does not guarantee proper operation. Evaluation in the actual application is needed to determine the correct constants.

■ Precautions

- This IC charges the delay capacitor through the delay capacitor pin (ICT) immediately when the voltage of one of batteries V1 to V4 reaches the overcharge voltage. Therefore, setting the resistor connected to the VCC pin to any value greater than the recommended level causes a reduction in the IC power supply voltage because of charge current of the delay capacitor. This may lead to a malfunction. DO NOT set the resistor to above the recommended value. If you change the resistance, please consult us.

- DO NOT connect any of overcharged batteries. Even if only one overcharged battery is connected to this IC, the IC detects overcharge, then charge current flows to the delay capacitor through the parasitic diode between pins where the battery is not connected yet. This may lead to a malfunction. Please perform sufficient evaluation in the case of use. Depending on an application circuit, even when the fault charge battery is not contained, the connection turn of a battery may be restricted in order to prevent the output of CO detection pulse at the time of battery connection.

For CMOS Output Active "H" and Nch Open Drain Models



- In this IC, the output logic of the CO pin is inverted after several milliseconds of internal delay if this IC is under the overcharge condition even ICT pin is either "V_{SS}-shortcircuit," "V_{DD}-shortcircuit" or "Open" status.

- Any position from V1 to V4 can be used when applying this IC for a one to three-cell battery. However, be sure to shortcircuit between pins not in use (SENSE-VC1, VC1-VC2, VC2-VC3, or VC3-VSS).

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

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

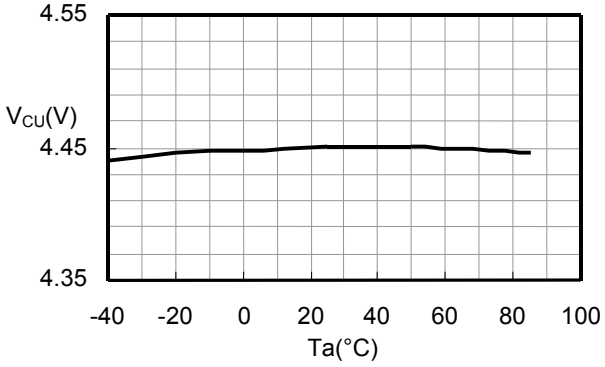
- SII claims no responsibility for any and all disputes arising out of or in connection with any infringement of the products including this IC upon patents owned by a third party.

■ Characteristic (Typical Data)

1. Detection Voltage vs Temperature

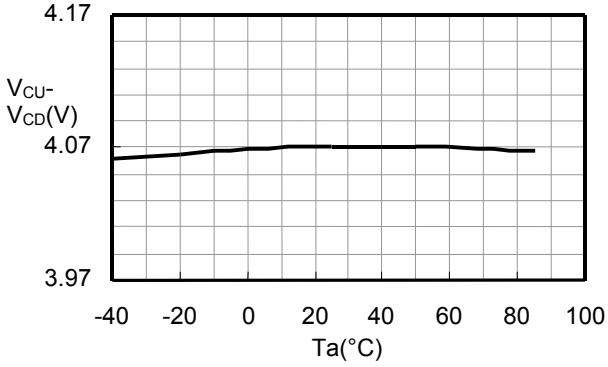
Overcharge Detection Voltage vs Temperature

S-8244AAAFN V_{CU}=4.45(V)



Overcharge Release Voltage vs Temperature

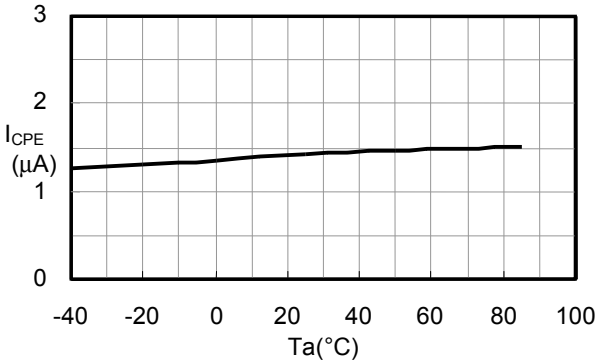
S-8244AAAFN V_{CD}=0.38(V)



2. Current Consumption vs Temperature

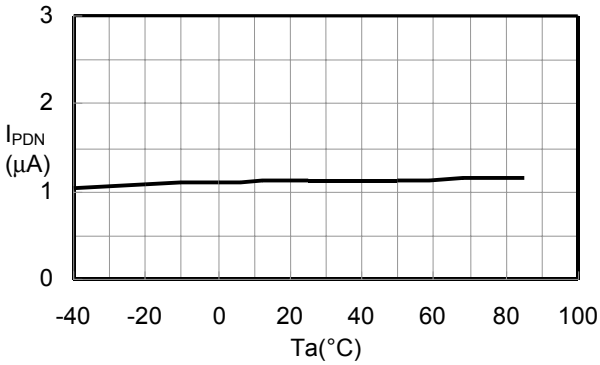
Current Consumption during Normal Operation vs Temperature

S-8244AAAFN V_{CC}=14.0(V)



Current Consumption at Power Down vs Temperature

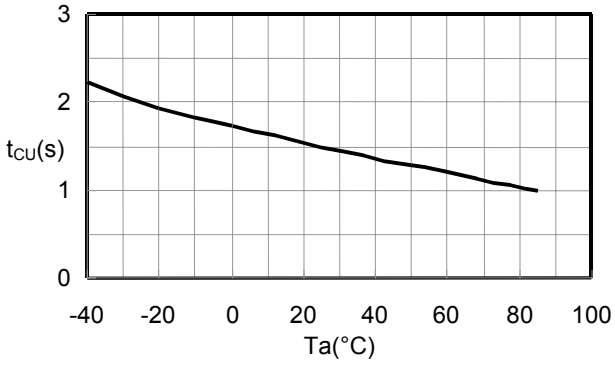
S-8244AAAFN V_{CC}= 9.2(V)



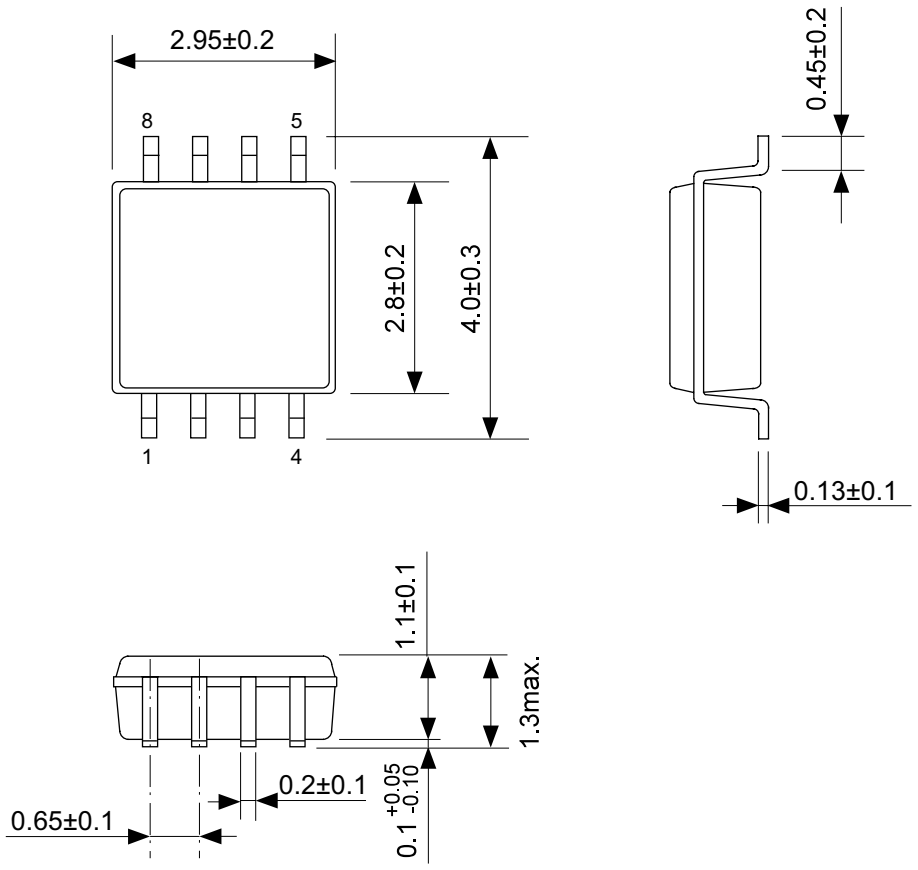
3. Delay Time vs Temperature

Overcharge Detection Delay Time vs Temperature

S-8244AAAFN V_{CC}=15.2(V)

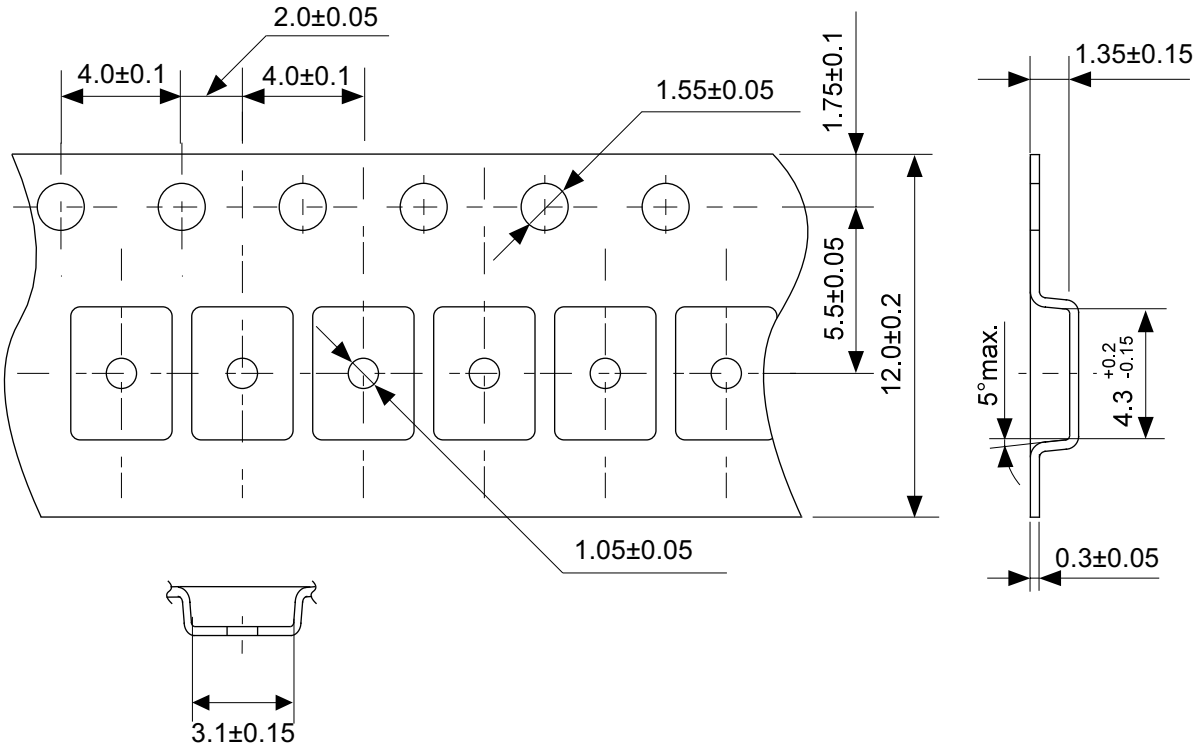


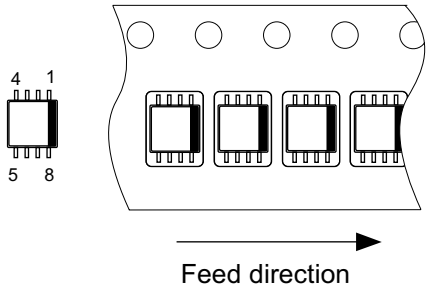
Caution Please design all applications of the S-8244 Series with safety in mind.



No. FN008-A-P-SD-1.1

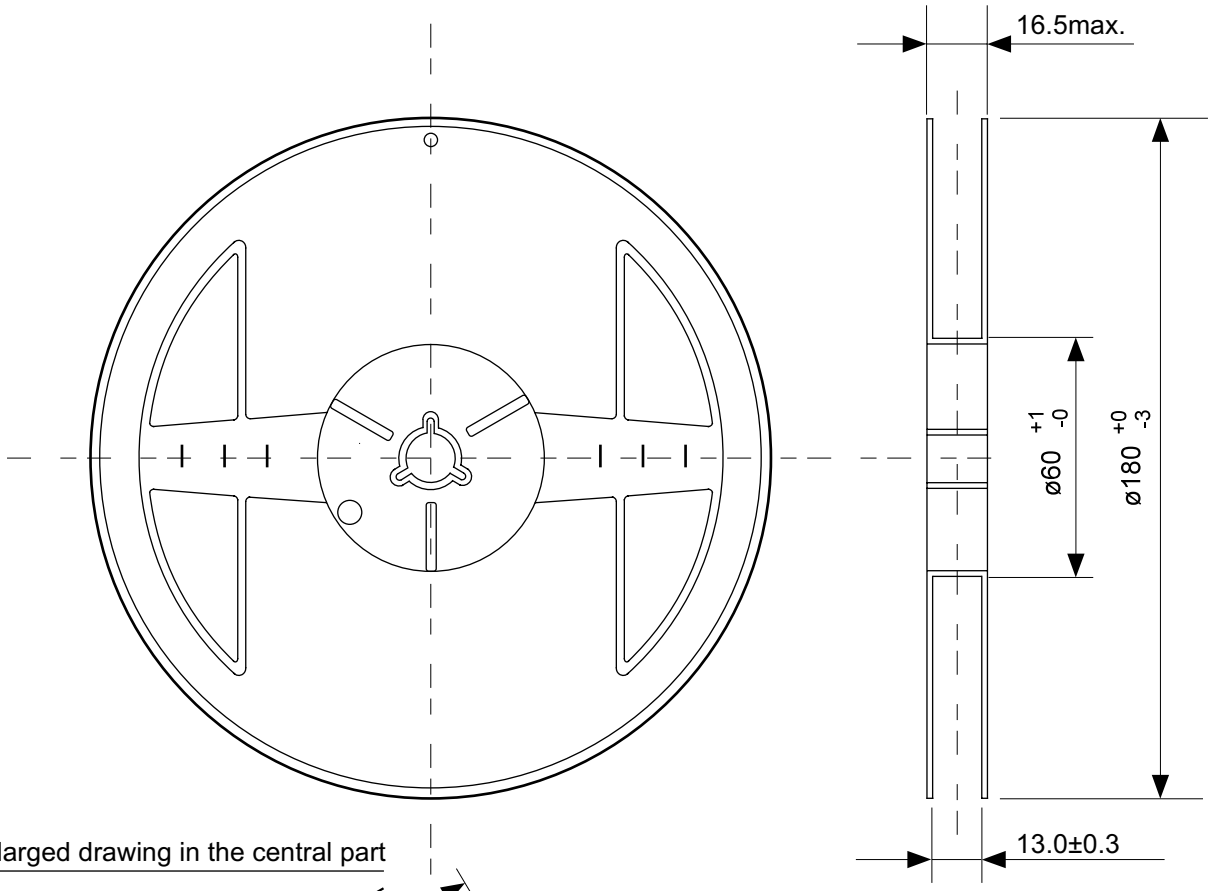
TITLE	MSOP8-A-PKG Dimensions
No.	FN008-A-P-SD-1.1
SCALE	
UNIT	mm
Seiko Instruments Inc.	



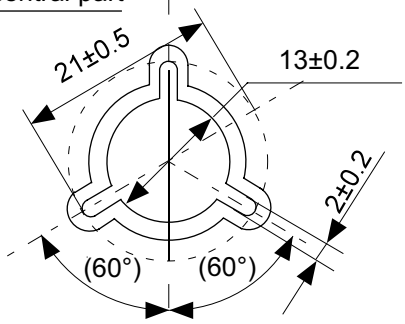


No. FN008-A-C-SD-1.1

TITLE	MSOP8-A-Carrier Tape
No.	FN008-A-C-SD-1.1
SCALE	
UNIT	mm
Seiko Instruments Inc.	



Enlarged drawing in the central part



No. FN008-A-R-SD-1.1

TITLE	MSOP8-A-Reel		
No.	FN008-A-R-SD-1.1		
SCALE		QTY.	3,000
UNIT	mm		
Seiko Instruments Inc.			

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