NISSHINBO

R5438L Series

1 to 3 Cells Li-Ion Battery Protection IC for Secondary Protection

OUTLINE

The R5438L is an overcharge protection IC for 1 to 3 serial cells Li-ion / Li-polymer rechargeable battery. This device provides the high-accuracy voltage detection function and the shutdown function can reduce the supply current to the minimum when all cell's voltage becomes less than the shutdown detection voltage.

FEATURES

- High Voltage Tolerant Process
  Absolute Maximum Ratings ································· 26 V
- Low Supply Current
  During Operation, Cell-voltage: 3.9 V, 3-Cells ············ Typ. 0.85 µA
- High-accuracy Voltage Detection
  Overcharge Detector Threshold (V_{DET1n}[1])·············· 4.10 V to 4.70 V, in 5 mV step
  Overcharge Detector Threshold Accuracy ················ ± 0.02 V (Ta = 25°C)
       ± 0.025 V (0°C ≤ Ta ≤ 60°C)
  Overcharge Release Voltage (V_{REL1n}[1])·················· V_{DET1n}–0V to V_{DET1n}–0.5V, in 50 mV step
  Overcharge Detection Delay Time ······················· 1-, 2-, 4-, or 6-sec with Delay Time Shortening Function[2]
  Overcharge Release Voltage Condition ·················· Voltage Release Type
- COUT Output (CMOS Output, Active-high)··············· Typ. 4.7 V
- Shutdown Functions
  Shutdown Detector Threshold ···························· Typ. 3.5 V ±0.3 V
  Shutdown Current··· Max.0.1µA
- 1 to 3 Cells Selectable Battery Protection
- Compact Package
  DFN1814-6C ·· 1.4mm x 1.8mm

APPLICATIONS

- Li-Ion or Li-Polymer Battery Protection

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[1] V_{DET1n}, V_{REL1n} : n =1, 2, 3
[2] The delay time can be reduced down to approx. 1/90 by applying a 4 V ± 0.2 V to the VDD – VC1 pins.

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SELECTION GUIDE

The overcharge and the delay time are user-selectable options.

Selection Guide

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R5438Lxxx$∗-TR	DFN1814-6C	5,000 pcs	Yes	Yes

xxx: Specify the combination of the overcharge detector threshold (V_{DET1n}) and the overcharge release voltage (V_{REL1n}) [1].

V_{DET1n} [2]: 4.10 V to 4.70 V in 5 mV step
V_{REL1n} [2]: $V_{DET1n} - 0$ V to $V_{DET1n} - 0.5$ V in 50 mV step

$: Specify the combination of the overcharge detection delay time (t_{VDET1}) and the overcharge release delay time (t_{VREL1}). Refer to *Delay Time Code Table* for details.

Delay Time Code Table

Code	t_{VDET1} (s)	t_{VREL1} (ms)
A	2	16
B	4	16
C	6	16
D	1	16

∗: Specify the function code.

Function Code Table

Code	Overcharge Released Condition	COUT Output	
A	Voltage Release	CMOS	"H" Active

[1] Refer to *Product Code Table* for details.
[2] V_{DET1n}, V_{REL1n}: n = 1, 2, 3

Product Code List

The product code is determined by the combination of the settable voltage (overcharge detector threshold: V_{DET1n} and overcharge release voltage: V_{REL1n}) and the delay time (overcharge detection delay time: t_{VDET1} and overcharge release delay time: t_{VREL1}) and the function code.
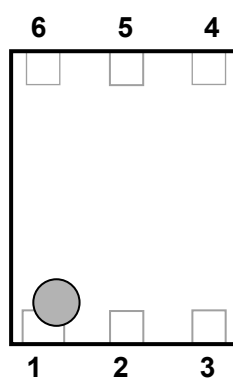
Product Code Table

Product Name	Settable Voltage (V)		Delay Time	
	V_{DET1n}	V_{REL1n}	$t_{VDET1}(s)$	$t_{VREL1}(ms)$
R5438L301AA	4.450	4.150	2	16
R5438L301BA	4.450	4.150	4	16
R5438L303AA	4.350	4.050	2	16
R5438L303BA	4.350	4.050	4	16
R5438L304AA	4.400	4.100	2	16
R5438L304BA	4.400	4.100	4	16
R5438L305AA	4.300	4.000	2	16
R5438L305BA	4.300	4.000	4	16
R5438L306CA	4.450	3.950	6	16
R5438L308BA	4.400	4.000	4	16
R5438L312AA	4.550	4.150	2	16
R5438L312BA	4.550	4.150	4	16
R5438L312CA	4.550	4.150	6	16
R5438L315AA	4.500	4.150	2	16
R5438L317BA	4.500	4.200	4	16
R5438L322BA	4.600	4.150	4	16
R5438L326DA	4.550	4.200	1	16
R5438L327AA	4.300	4.200	2	16
R5438L328BA	4.600	4.250	4	16
R5438L329BA	4.650	4.300	4	16
R5438L330AA	4.200	4.100	2	16
R5438L331BA	4.700	4.350	4	16
R5438L332BA	4.540	4.200	4	16

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BLOCK DIAGRAM

R5438L Block Diagram

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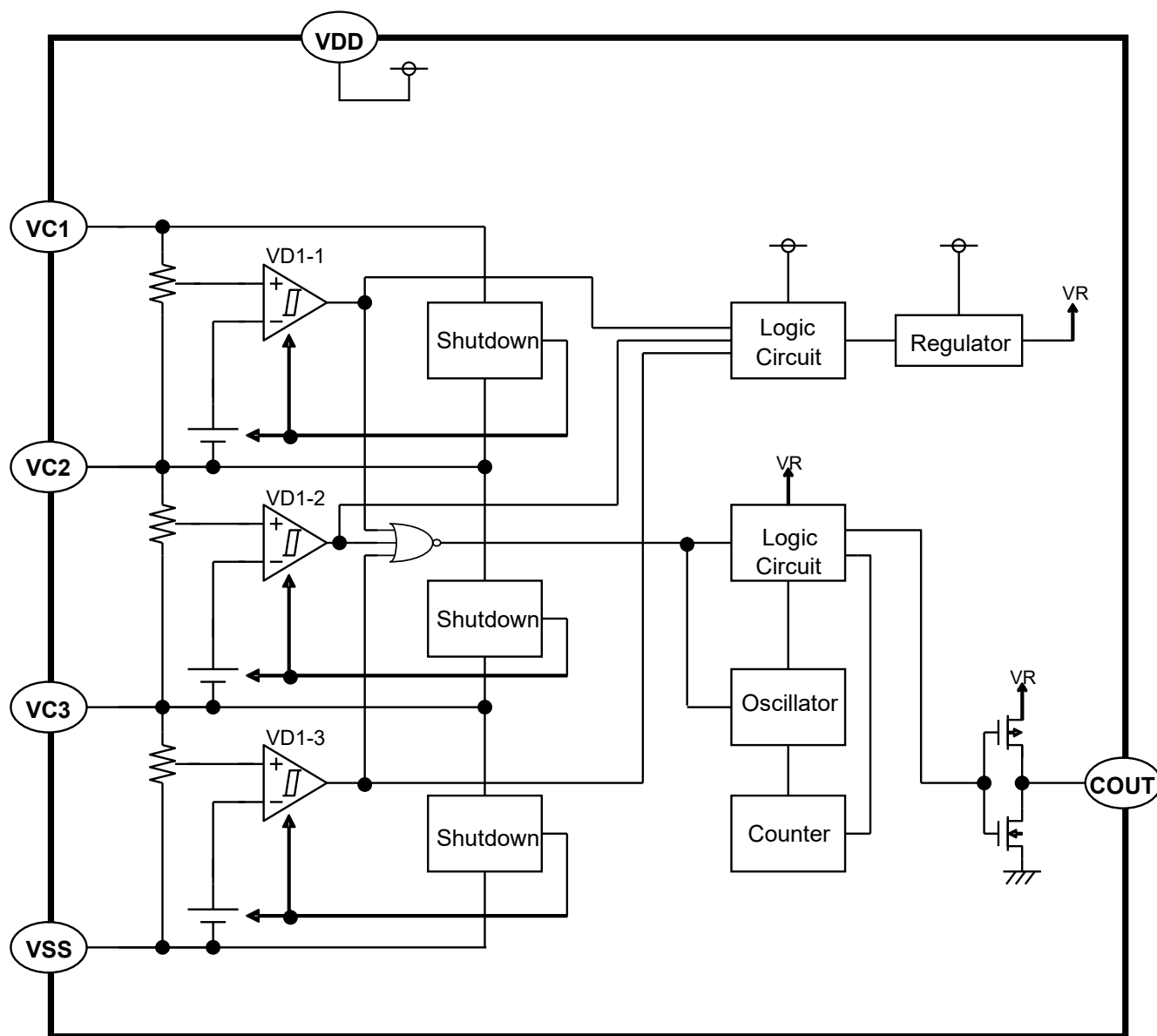
PIN DESCRIPTIONS

DFN1814-6C

```
    6     5     4
   ┌───┐ ┌───┐ ┌───┐
   └───┘ └───┘ └───┘
  ┌─────────────────┐
  │                 │
  │                 │
  │  ⬤              │
  └─────────────────┘
   ┌───┐ ┌───┐ ┌───┐
   └───┘ └───┘ └───┘
    1     2     3
```

DFN1814-6C Pin Assignment

Pin No.	Symbol	Description
1	COUT	Overcharge Detection Output Pin
2	VDD	Power Supply Pin
3	VC1	CELL1 Plus Pin
4	VC2	CELL2 Plus Pin
5	VC3	CELL3 Plus Pin
6	VSS	IC Ground Pin

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ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings   (Ta = 25°C, V_{SS} = 0 V)

Symbol	Item	Rating	Unit
V_{DD}	Power Supply Voltage	V_{C1}-0.3 to V_{C1}+6.5	V
		V_{C1}-0.3 to 26	V
V_{C1}	CELL1 Plus Pin Input Voltage	V_{C2}-0.3 to V_{C2}+6.5	V
V_{C2}	CELL2 Plus Pin Input Voltage	V_{C3}-0.3 to V_{C3}+6.5	V
V_{C3}	CELL3 Plus Pin Input Voltage	-0.3 to 6.5	V
V_{COUT}	COUT Pin Output Voltage	-0.3 to V_{OH1}+0.3	V
P_D	Power Dissipation (Standard Land Pattern)	150	mW
Tj	Junction Temperature Range	-40 to 125	°C
Tstg	Storage Temperature Range	-55 to 125	°C

ABSOLUTE MAXIMUM RATINGS
Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause permanent damage and may degrade the lifetime and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings is not assured.

RECOMMENDED OPERATING CONDITION

Symbol	Item	Rating	Unit
V_{DD}	Operating Input Voltage	1.5 to 20 / V_{C1} +5 V	V
Ta	Operating Temperature Range	−40 to 85	°C

RECOMMENDED OPERATING CONDITIONS
All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

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ELECTRICAL CHARACTERISTICS

V_{CELLn} = CELLn (Ex. V_{CELL1} is a voltage difference between VC1 and VC2)

n = 1, 2, 3, unless otherwise noted

The specifications surrounded by ☐ are guaranteed by Design Engineering at 0°C ≤ Ta ≤ 60°C.

R5438L Electrical Characteristics (Ta = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	Circuit (1)
V_{DET1n}	CELLn Overcharge Detection Voltage	Detect rising edge of supply voltage	V_{DET1n} -0.020V V_{DET1n} -0.025V	V_{DET1n}	V_{DET1n} +0.020V V_{DET1n} +0.025V	V	A
V_{REL1n}	CELLn Overcharge Release Voltage	Detect falling edge of supply voltage	V_{REL1n} -0.050V	V_{REL1n}	V_{REL1n} +0.050V	V	A
t_{VDET1}	Overcharge Detection Delay Time	V_{CELLn}=3.9 V (n=2,3) V_{CELL1}=3.9 V → 4.7 V	t_{VDET1} x 0.8	t_{VDET1}	t_{VDET1} x 1.2	s	B
t_{VREL1}	Overcharge Release Delay Time	V_{CELLn}=3.9 V (n=2,3) V_{CELL1}=4.7 V → 3.9 V	12.8	16	19.2	ms	B
V_{SHT}	Shutdown Detection Voltage	Detect falling edge of supply voltage	3.2	3.5	3.8	V	C
V_{OH1}	C_{OUT} Pch. ON Voltage 1	I_{OH}=0µA,V_{CELLn} = 4.7 V	4.0	4.7	5.4	V	D
		I_{OH}=0µA,V_{CELLn} = 4.7 V (n=1, at 1 cell protection)		V_{DD}			
V_{OH2}	C_{OUT} Pch. ON Voltage 2	I_{OH}= -50µA, V_{CELLn} = 4.7V	V_{OH1} -0.5V	V_{OH1}-0.1V		V	E
V_{OL}	C_{OUT} Nch. ON Voltlage	I_{OL}=50µA,V_{CELLn}=3.9 V		0.1	0.5	V	F
I_{SHT}	Shutdown Current	V_{CELLn} = 3.1 V			0.1	µA	G
I_{SS}	Supply Current	V_{CELLn} = 3.9 V		0.85	1.7	µA	G
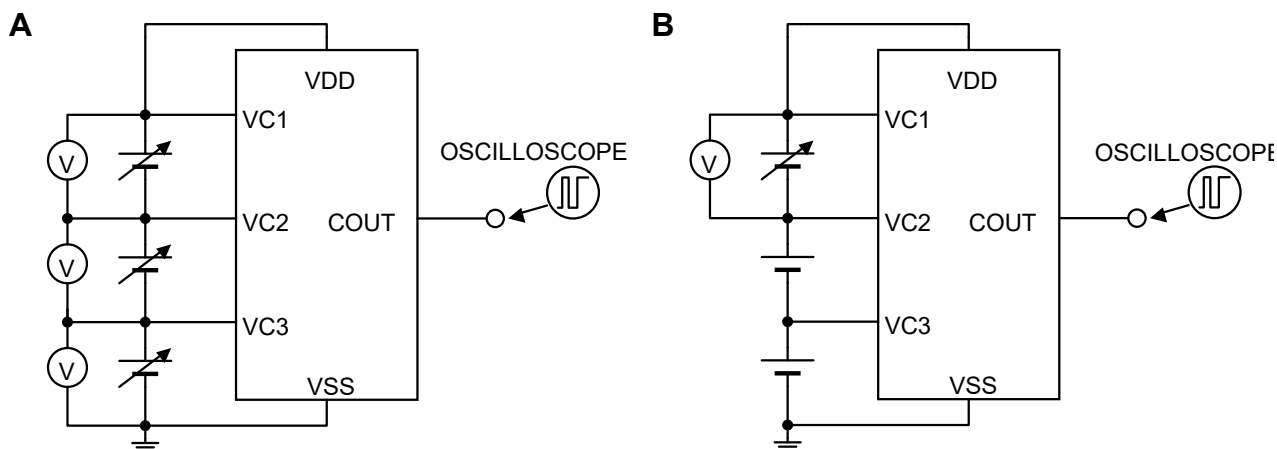
TEST CIRCUITS

(1) Refer to *TEST CIRCUITS* for detail information.

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C

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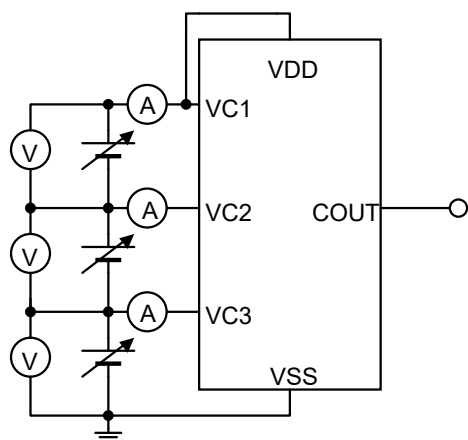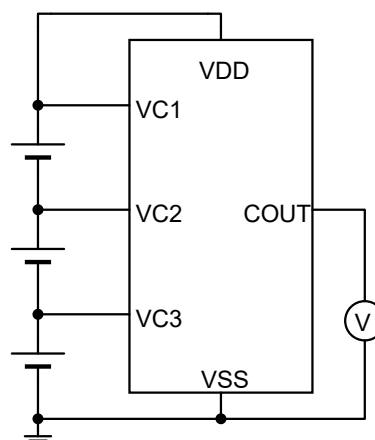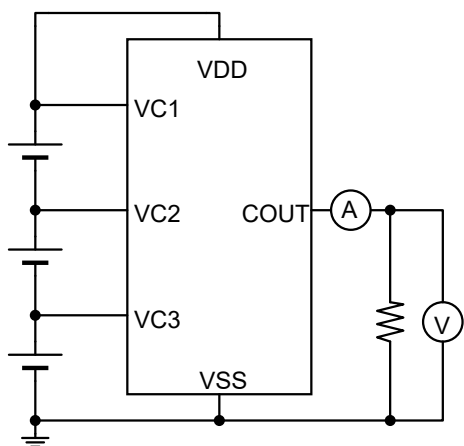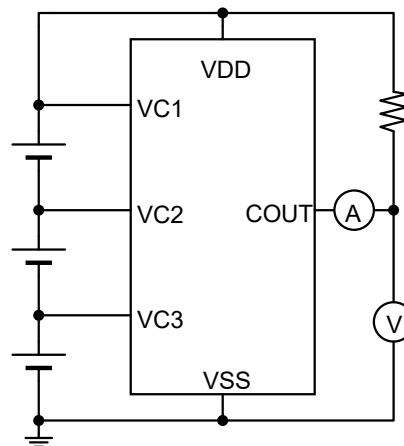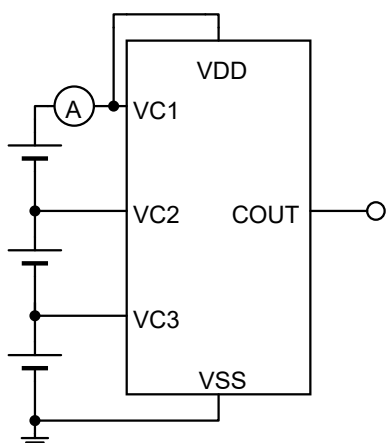
THEORY OF OPERATION

Overcharge Detection Circuit, VD1-n (n = 1, 2, 3)

(See the following timing chart)

While the cells are charged, the voltage between VC1 pin and VC2 pin (Cell-1 voltage), the voltage between VC2 pin and VC3 pin (Cell-2 voltage), and the voltage between VC3 pin and VSS pin (Cell-3 voltage) are supervised. If at least one of the cells' voltage becomes equal or more than the overcharge detector threshold, the overcharge is detected, and an external charge control Nch. FET turns on with COUT pin being at "H" level and by cutting a fuse on the charger path, and charge stops.

To reset the overcharge and make the COUT pin level to "L" again after detecting over-charge, in such conditions that a time when all the cells' voltages are down to a level lower than overcharge released voltage. Internal fixed output delay times for overcharge detection and release from over-charge exist. Even if one of voltage of the cells keeps its level more than the overcharge detector threshold, and output delay time passes, overcharge voltage is detected. After detecting overcharge, even if all the cell voltages become equal or less than the released voltage from overcharge, if at least one of the cells voltage becomes higher than the released voltage from overcharge within the output delay time of the release from overcharge, then overcharge is not released.

The output type of the COUT pin is CMOS output between VSS and the built-in regulator, and "H" level of COUT pin is the output voltage of the built-in regulator.

Shutdown Function

The voltage between VC1 pin and VC2 pin (Cell-1 voltage), the voltage between VC2 pin and VC3 pin (Cell-2 voltage), and the voltage between VC3 pin and VSS pin (Cell-3 voltage) are supervised.   If the cell voltage becomes equal or less than the shutdown detector threshold, the overcharge detector of the cell is halted, as a result, the consumption current of IC itself (Shutdown current) is extremely reduced. If at least one of the cells voltage becomes higher than the shutdown detection voltage, the shutdown detection is released.

Delay Shortening (DS) Function

Applying a voltage of 4 V ± 0.2 V between VDD and VC1 can shorten the overcharge detection delay time (t_{VDET1}) into approximately 1/90, likewise, the overcharge release delay time (t_{VREL1}) into approximately 1/60.

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1-cell/ 2-cell Protection Alternative

By short-circuiting between cells, this device can meet as a protection IC for 1 or 3 cells placed in series.
The following table indicates pins to short-circuit depending on protected cells.

Protected Cells	Pins to short-circuit
1-cell protection	VC1 and VC2 pins, and VC3 and VSS pins
2-cell protection	VC1 and VC2 pins, or VC3 and VSS pins

If providing other connections except above short-circuit for 1 or 2 cells protection, perform thorough evaluation using the actual devices.
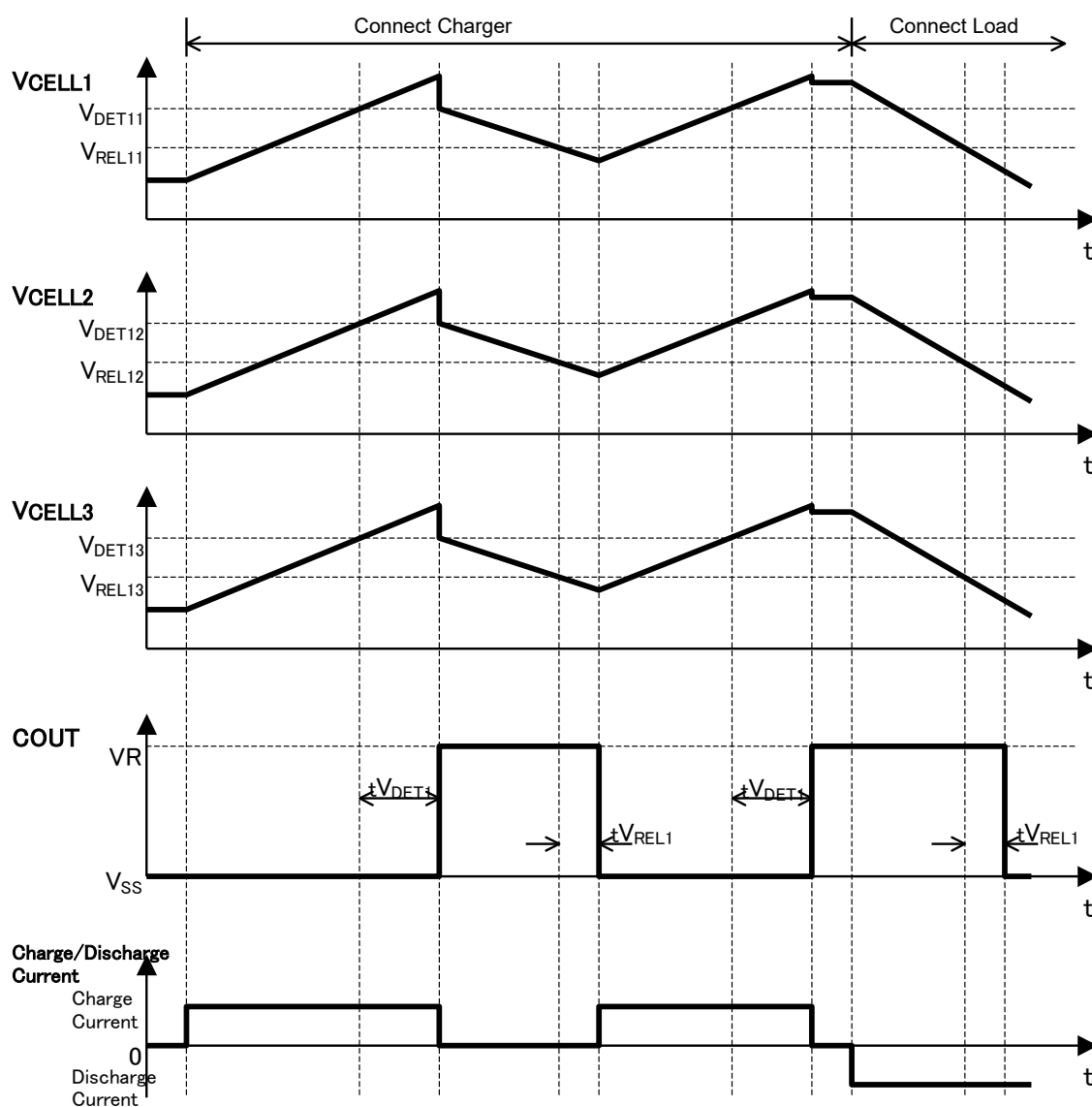
Overcharge Operation Timing Chart

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APPLICATION INFORMATION

Typical Application Circuits in Normal Mode (CMOS Output, Active-high)

As for the order of cell's connection, connect a positive terminal of CELL1 as the end terminal. If connected another terminal, a fuse blowout might be caused by transiently "High" output of the COUT pin.
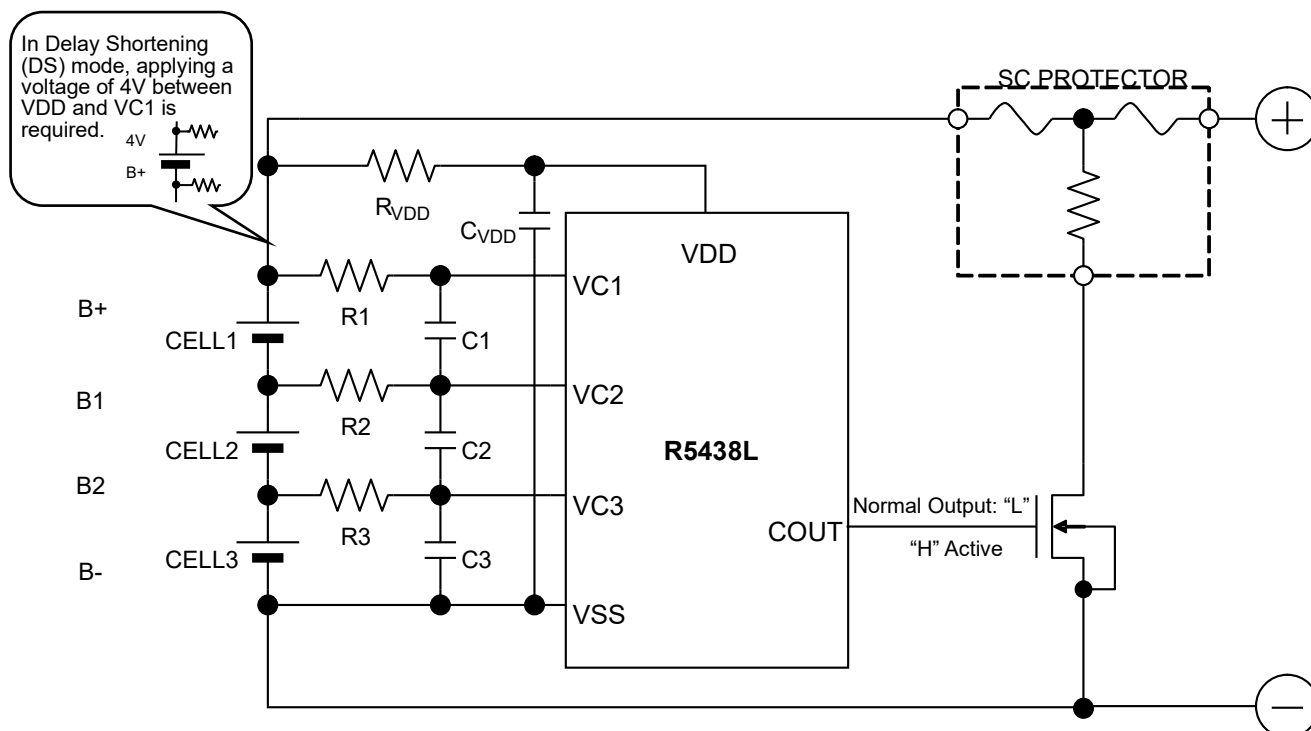
Typical Application Circuit for 3-cell Protection

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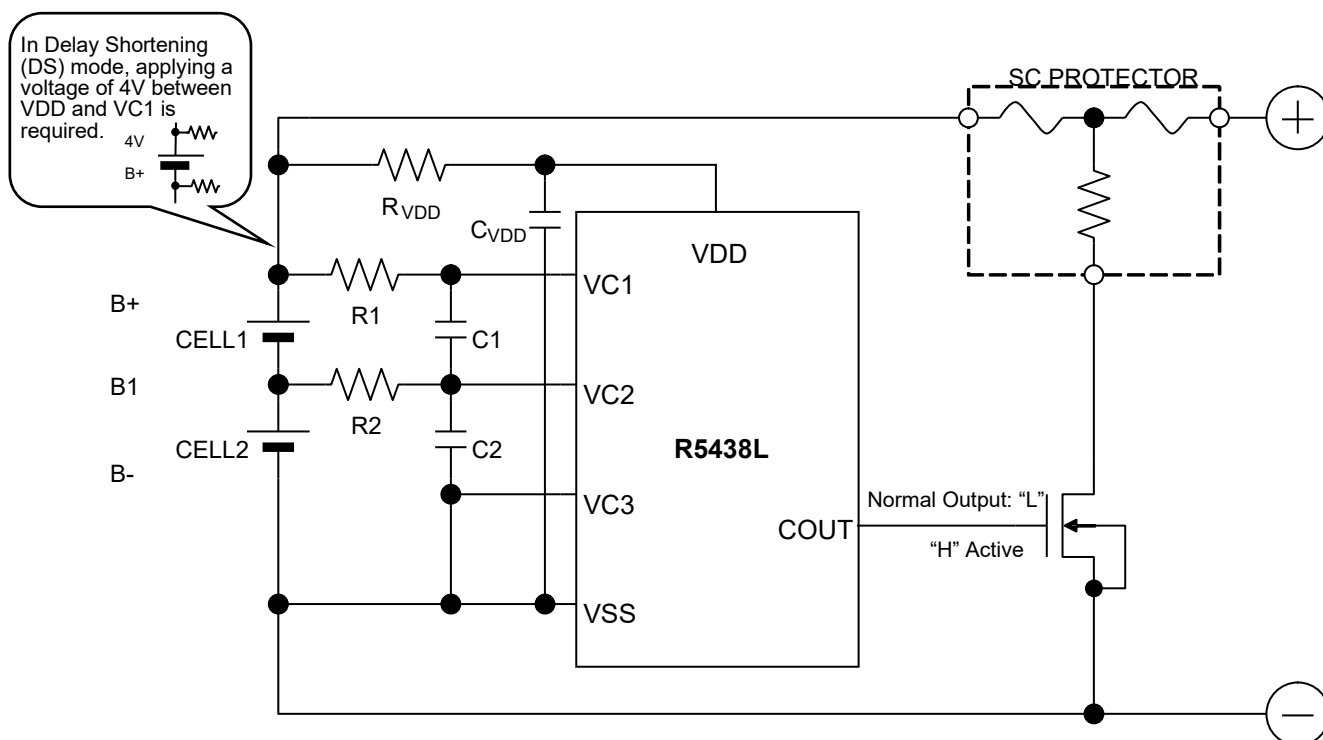
Typical Application Circuit for 2-cell Protection -1

Typical Application Circuit for 2-cell Protection -2

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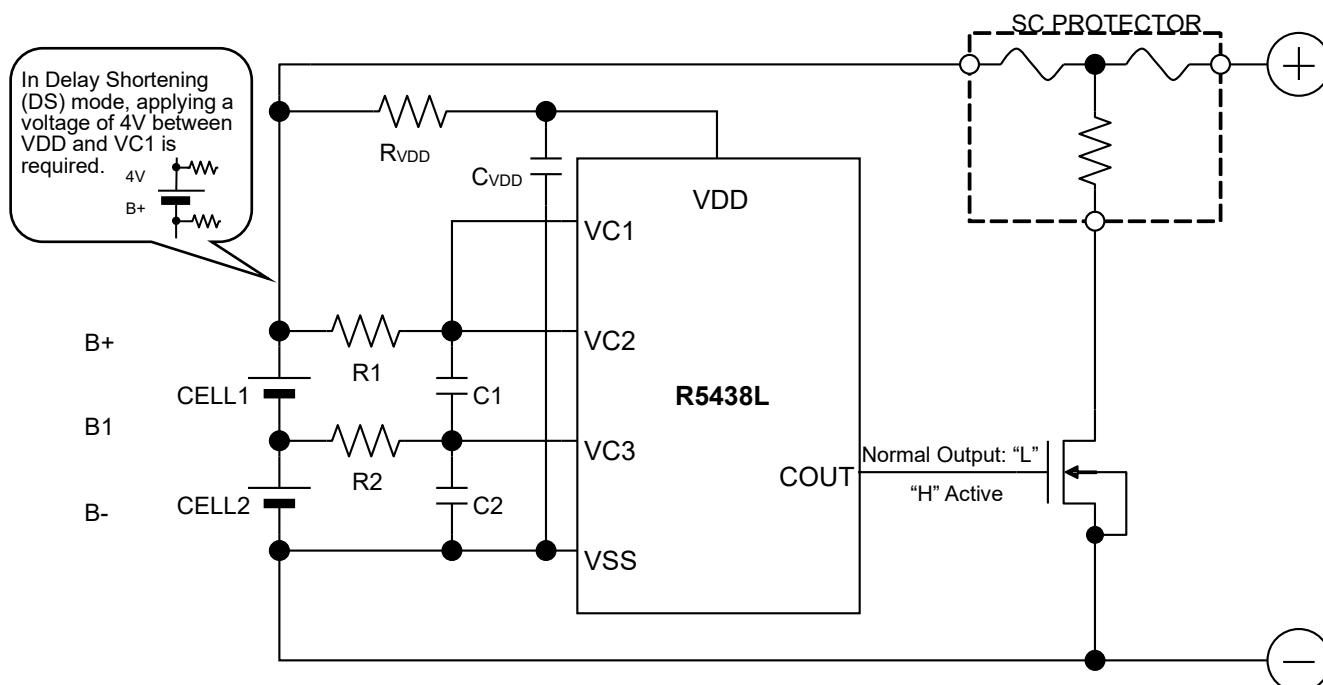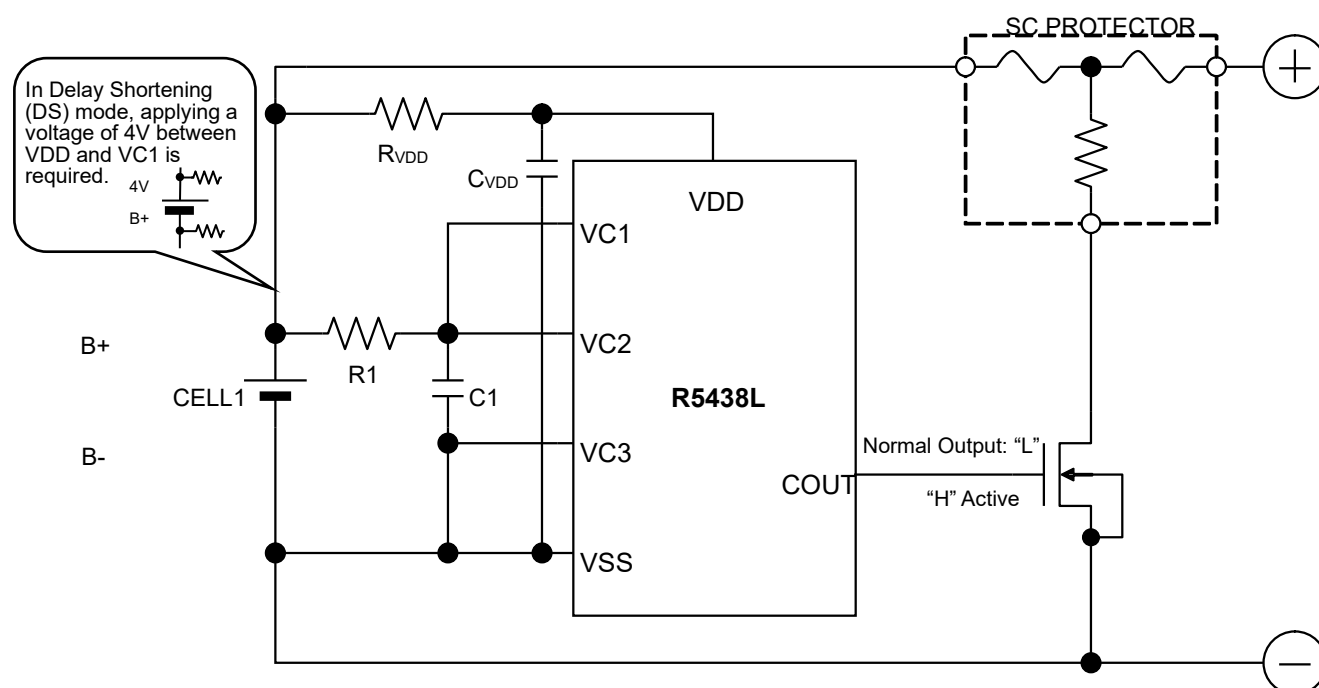
Typical Application Circuit for 1-cell Protection

External Components

Symbol	Typ.	Unit	Range
R_{VDD}	100	Ω	100 to 1000
R1	1000	Ω	330 to 1000
R2	1000	Ω	330 to 1000
R3	1000	Ω	330 to 1000
C_{VDD}	0.1	μF	0.01 to 1
C1	0.1	μF	0.01 to 1
C2	0.1	μF	0.01 to 1
C3	0.1	μF	0.01 to 1

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Technical Notes on the Selection Components

● The voltage fluctuation is stabilized with R_{VDD} and C_{VDD}. If a small R_{VDD} is set, in the case of the large transient may happen to the cell voltage, by the flowing current, the IC may be unstable. If a large R_{VDD} is set, by the consumption current of the IC itself, the voltage difference between VDD pin and VC1 pin is generated, and unexpected operation may result. Therefore, the appropriate value range of R_{VDD} is from 100 Ω to 1 kΩ. To make a stable operation of the IC, the appropriate value range of C_{VDD} is from 0.01 μF to 1.0 μF.

● The voltage fluctuation is stabilized with R1 to R3 and C1 to C3. If a R1 to R3 is too large, by the conduction current at detection, the detector threshold may shift higher. Therefore, the appropriate value range of R1 to R3 is equal or less than 1 kΩ. To make a stable operation of the IC, the appropriate value range of C1 to C3 is 0.01 μF or more.

● The typical application circuit diagrams are just examples. This circuit performance largely depends on the PCB layout and external components. In the actual application, fully evaluation is necessary.

● Overvoltage and the over current beyond the absolute maximum rating should not be forced to the protection IC and external components. During the time until the fuse is open after detecting overcharge, a large current may flow through the FET. Select an FET with large enough current capacity in order to endure the large current.

● To connect the SC protector, connect the SC protector to the cell must be the last.

Contact Information for Inquiries regarding SC PROTECTOR

Dexerials Corporation (Sony Chemical & Information Device Company Ltd.)
 URL: http://www.dexerials.jp

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TYPICAL CHARACTERISTICS

Part1. vs. Temperature

1) Celln Overcharge Detection Threshold vs. Temperature

R5438L301AA
$V_{CELL}n=3.9V(n=1,2,3)$
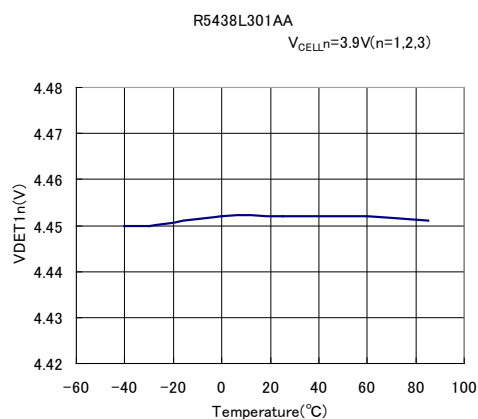
2) Celln Overcharge Release Voltage vs. Temperature

R5438L301AA
$V_{CELL}n=3.9V(n=1,2,3)$
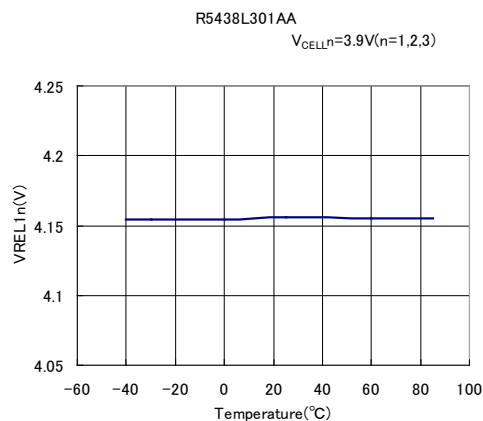
3) Overcharge Output delay Time vs. Temperature

R5438L301AA
$VCELLn=3.9V(n=2,3). V_{CELL}1=3.9V \rightarrow 4.7V$

R5438L306CA
$VCELLn=3.9V(n=2,3). V_{CELL}1=3.9V \rightarrow 4.7V$
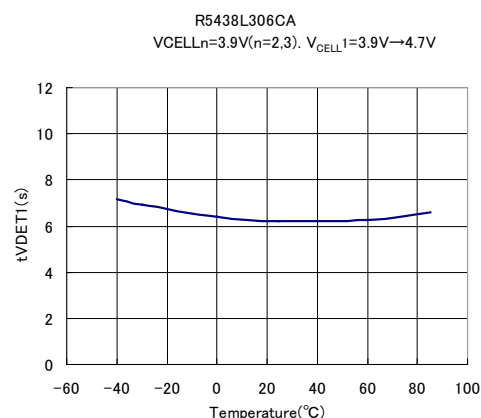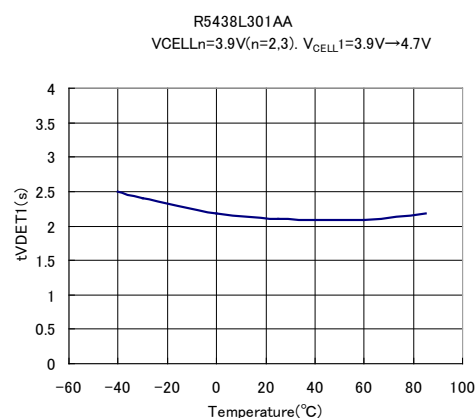
4) Released Delay Time from Overcharge vs. Temperature

R5438L301AA
$VCELLn=3.9V(n=2,3). V_{CELL}1=4.7V \rightarrow 3.9V$
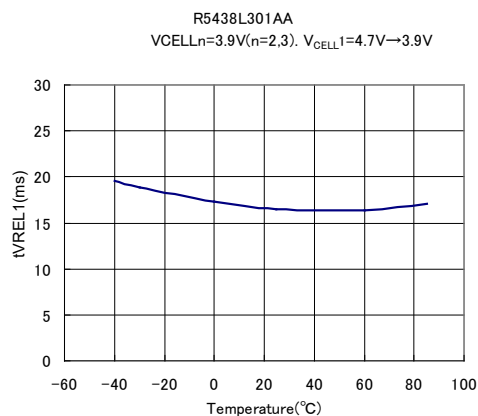
5) Celln Shutdown Threshold vs. Temperature

R5438L301AA
$V_{CELL}n=3.1V(n=1,2,3)$

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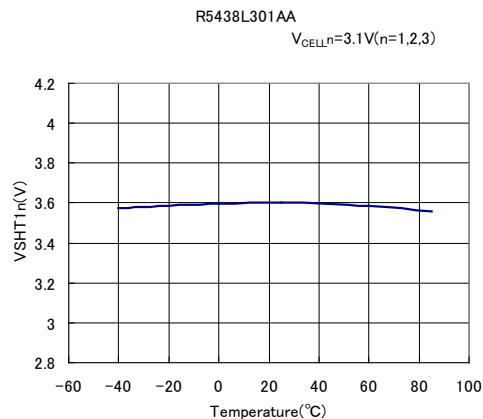
6) COUT **Pch. On Voltage (No Load)
    vs. Temperature**

R5438L301AA
$V_{CELL}n=4.7V(n=1,2,3),I_{OH}=0uA$

7) COUT **Pch. On Voltage vs. Temperature**
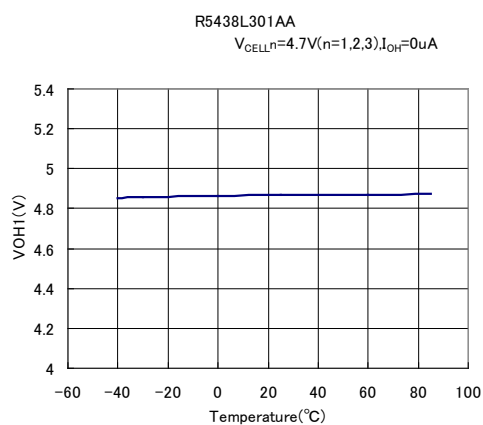
R5438L301AA
$V_{CELL}n=4.7V(n=1,2,3),I_{OH}=-50uA$
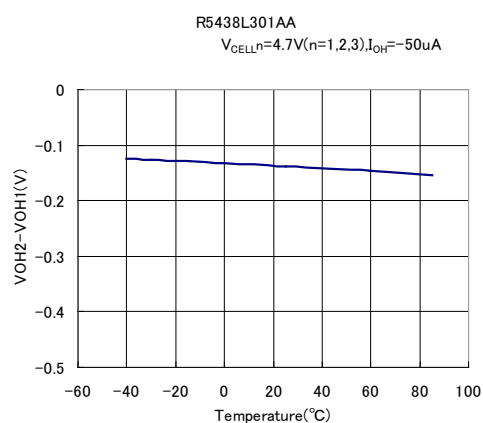
8) COUT **Nch. On Voltage vs. Temperature**

R5438L301AA
$V_{CELL}n=3.9V(n=1,2,3),I_{OH}=50uA$
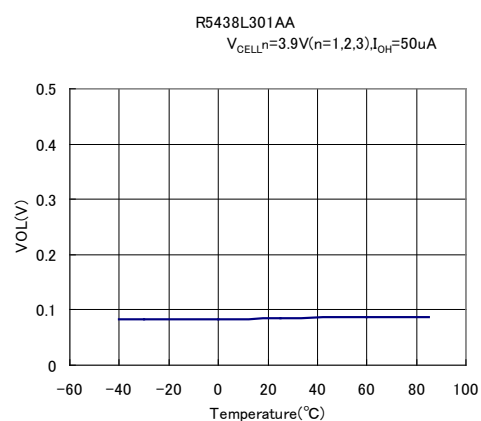
9) Shutdown Current vs. Temperature

R5438L301AA
$V_{CELL}n=3.1V(n=1,2,3)$
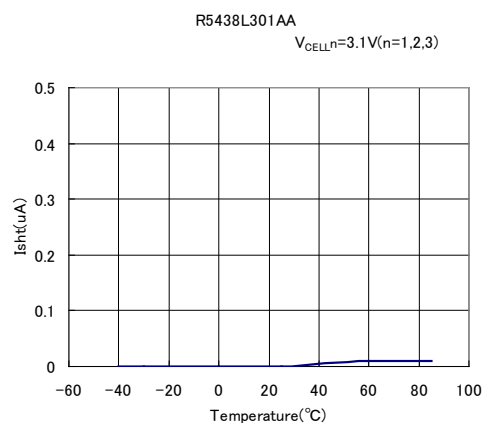
10) Supply Current vs. Temperature

R5438L301AA
$V_{CELL}n=3.9V(n=1,2,3)$
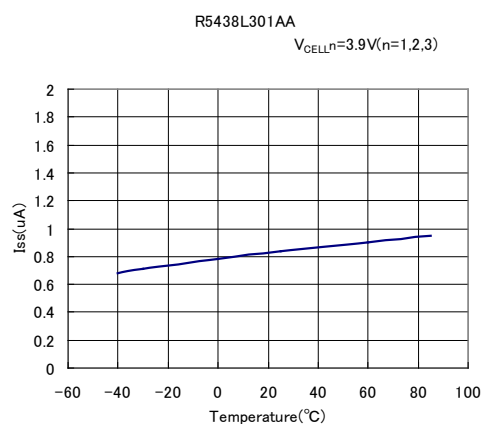
Part2. Supply Current vs. VDD (R5438L301AA)

3-cell Protection Supply Current vs. VDD

R5438L301AA

Test Circuit

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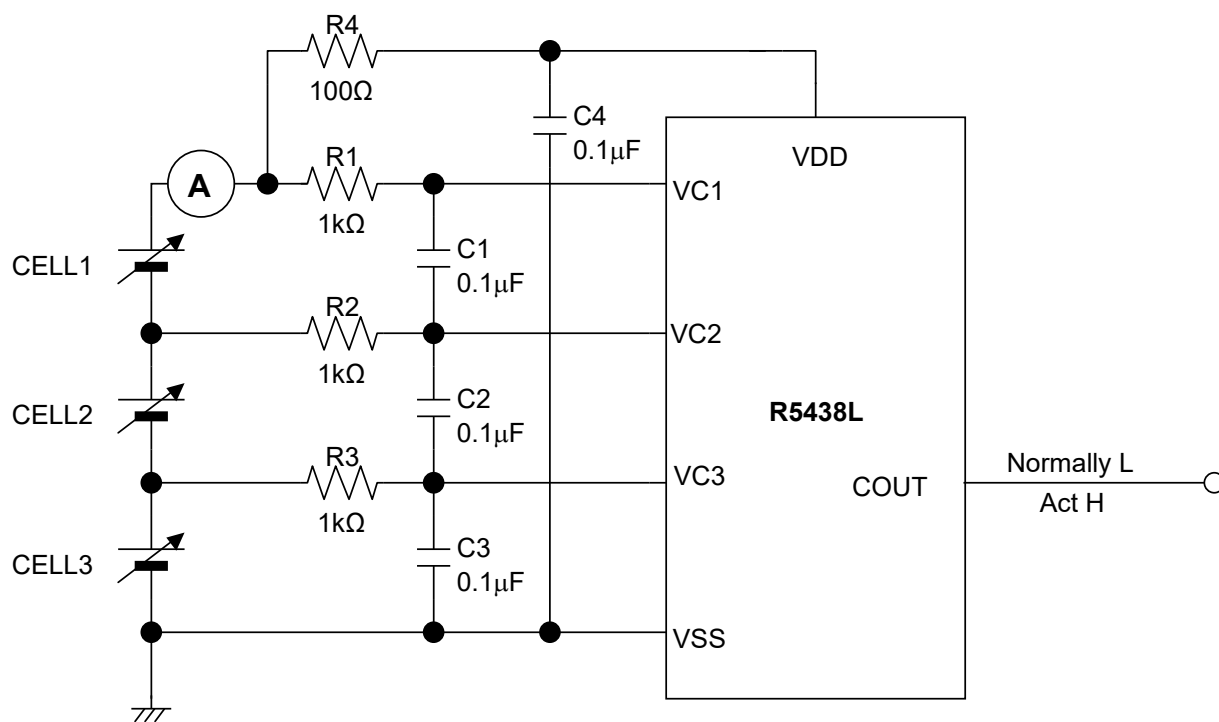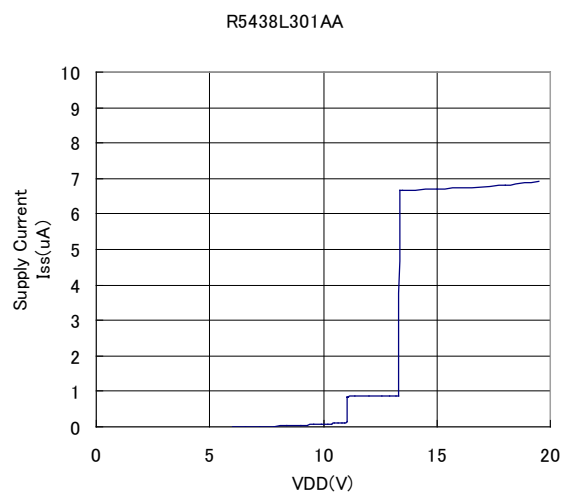
Part3. vs. External Resister Dependence (R5438L301AA)

Overcharge Detection Voltage / Overcharge Release Voltage vs. R1

R5438L301AA

VDET11 ——— VREL11 – – –

Test Circuit

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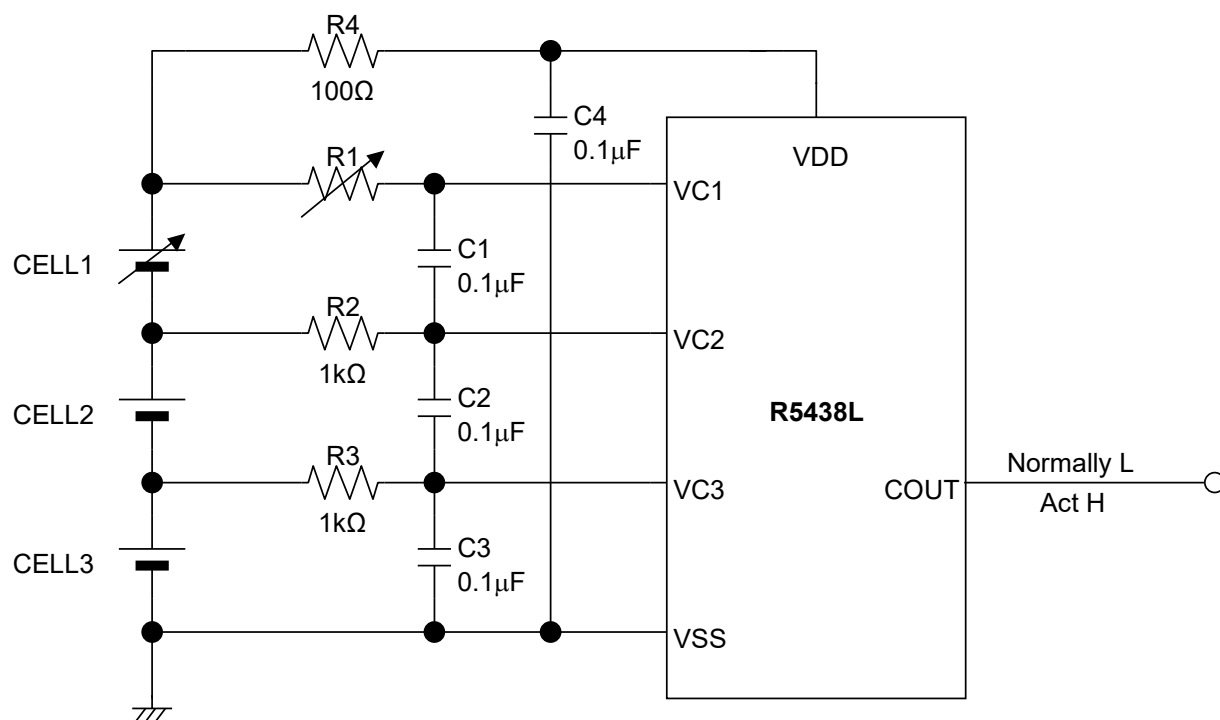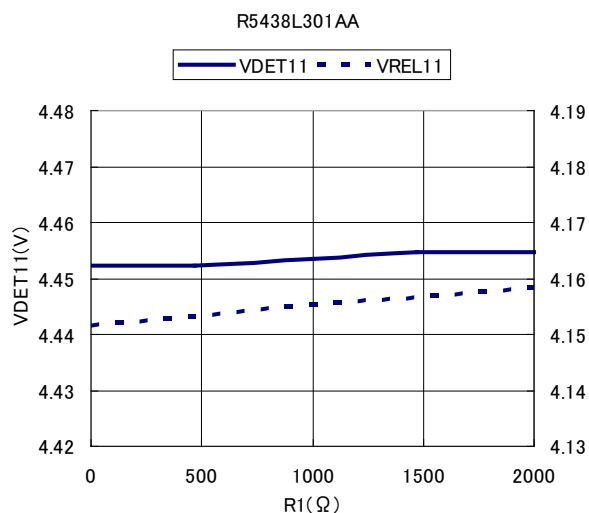
TECHNICAL NOTES

A peripheral component or the device mounted on PCB should not exceed a rated voltage, a rated current or a rated power. When designing a peripheral circuit, please be fully aware of the following points.

- Please evaluate the product at the PCB level before use, as some symptoms may remain that cannot be confirmed by the evaluation at the IC level.

- When using any coating or underfill to improve moisture resistance or joining strength, evaluate them adequately before using. In certain materials or coating conditions, corrosion by contained constituents, current leakage by moisture absorption, crack and delamination by physical stress can happen. If the curing temperature of the coating material or underfill material exceeds the absolute maximum rating, the electrical characteristics of this product may change.

- When performing X-ray inspection in mass production process and evaluation build stage such as the product functions and characteristics confirmation, please confirm X-ray irradiation does not exceed 1.5Gy (absorbed dose for air).

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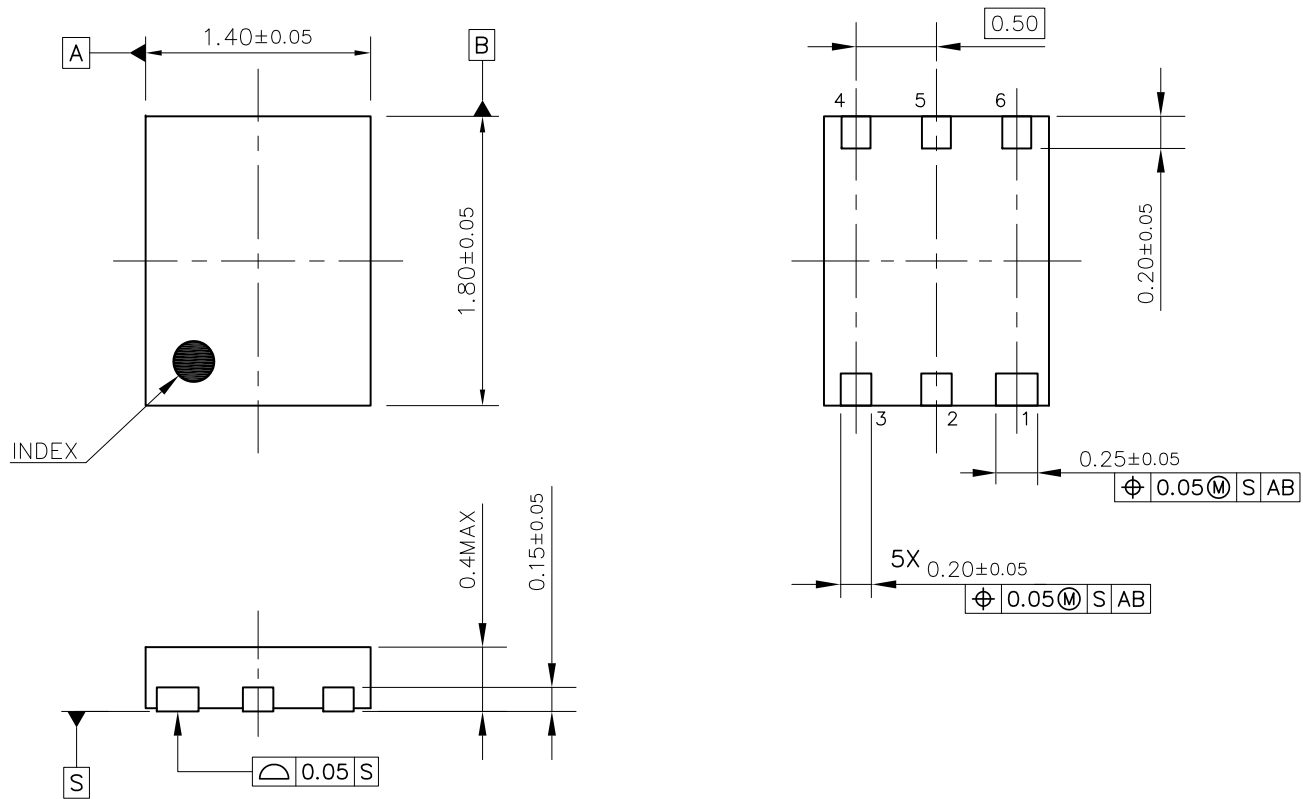
DFN1814-6C Package Dimensions (Unit: mm)

Ver. J

①②: Product Code ⋯ Refer to *Part Marking List*
③④: Lot Number ⋯ Alphanumeric Serial Number
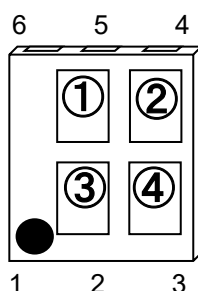
R5438L (DFN1814-6C) Part Markings

NOTICE
There can be variation in the marking when different AOI (Automated Optical Inspection) equipment is used. In the case of recognizing the marking characteristic with AOI, please contact our sales or distributor before attempting to use AOI.

R5438LxxxxA Part Marking List

Product Name	①	②	製品名	①	②
R5438L301AA	H	A	R5438L329BA	J	D
R5438L306CA	H	B	R5438L330AA	J	E
R5438L301BA	H	C	R5438L331BA	J	F
R5438L305BA	H	D	R5438L332BA	J	G
R5438L308BA	H	E	R5438L312CA	J	H
R5438L305AA	H	F			
R5438L303AA	H	G			
R5438L312BA	H	H			
R5438L304AA	H	J			
R5438L304BA	H	K			
R5438L312AA	H	L			
R5438L303BA	H	M			
R5438L315AA	H	N			
R5438L317BA	H	P			
R5438L322BA	H	R			
R5438L326DA	H	S			
R5438L327AA	H	Y			
R5438L328BA	J	B			

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