Li-ION/POLYMER 1/2/3-CELL PROTECTOR Second protection IC

NO.EA-324-140808

OUTLINES

R5437/R5438 Series are CMOS-based high voltage tolerant over-charge protection ICs for Li-ion/Li-polymer secondary battery. The R5437/R5438 can detect overcharge of 1-cell to 3-cell Li-ion/ Li-polymer batteries. The R5437/R5438 is consists of 3 voltage detectors, a voltage reference unit, an internal voltage regulator, an oscillator, a counter, a delay circuit, a logic circuit.

When the over-charge is detected, after the IC internally fixed delay time, the output of C_{OUT} becomes "H".

After detecting over-charge, when the cell voltage becomes lower than the over-charge released voltage, the over-charge state is released.

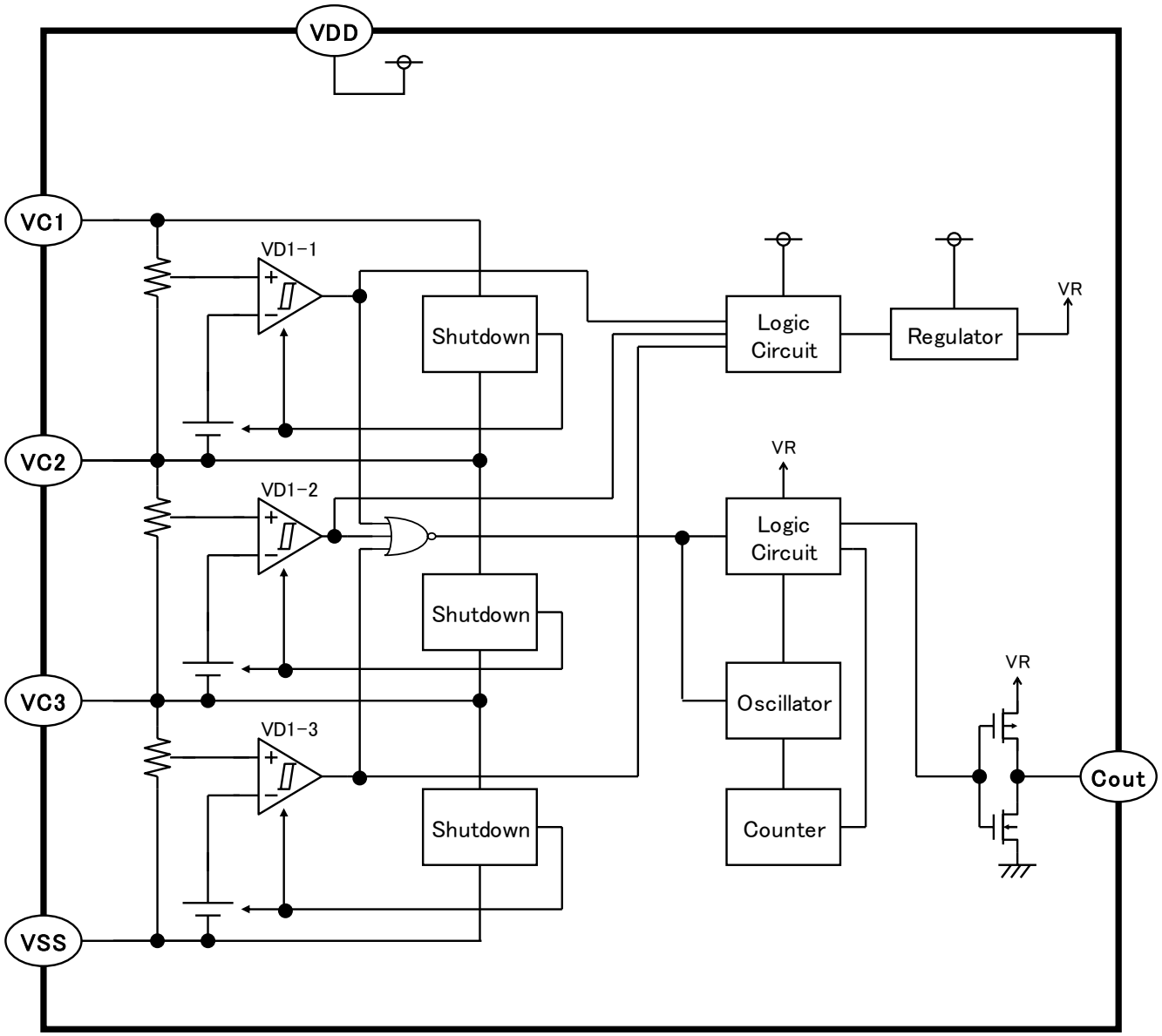
If all the cells voltages become equal or less than the shutdown detector threshold, all the circuits are halted and shut down, as a result, the consumption current of IC itself (Shutdown current) is extremely reduced.

The output type is CMOS.

FEATURES

- Manufactured with High Voltage Tolerant Process ..... Absolute Maximum Rating 26V
- Low supply current ..... Cell voltage 3.9V, for 3-cell Typ. 0.85μA
- High accuracy detector threshold ..... Over-charge detector (Ta=25°C) ±20mV
  (Ta=0 to 60°C) ±25mV
- Variety of detector threshold
  Over-charge detector threshold 4.1V-4.6V step of 0.005V ($V_{DET1}n$) (n=1, 2, 3)
  Over-charge released voltage $V_{DET1}n$-0V to $V_{DET1}n$-0.5V step of 0.05V ($V_{REL1}n$) (n=1, 2, 3)
- Setting of Output delay time..... Over-charge detector Output Delay options 2, 4, 6s(Built-in delay)
- Shutdown Function .....When all the cell voltages become equal or less than shutdown detector threshold, the IC will be into shutdown mode and the consumption current of IC itself becomes extremely small. Even if one of the cells becomes equal or more than shutdown released voltage, the shutdown mode is released.
- Shutdown detector threshold .....Typ. 3.5V±0.3V
- Shutdown Release Hysteresis .....none
- Shutdown current .....Max. 0.1μA
- 1/2/3 cell protection enabler .....By external wiring, 1 or 2 or 3-cell protection can be selected.
- Over-charge released condition .....Released by voltage type
- C_{OUT} output .....C_{OUT}: 4.7V regulator power supply CMOS output. Active "H"
- Delay Time Shortening Function .....By applying the voltage of 4V±0.2V to VDD-VC1, over-charge and released delay time can be shortened to 1/90.
- Small package..... DFN1814-6

BLOCK DIAGRAM



SELECTION GUIDE

In the R5437/R5438Lxxxxx Series, input threshold of over-charge and output delay time can be designated according to the application.

Part Number is designated as follows:

(ex.)

R5437L 301BA ←Part Number
↑ ↑ ↑↑
a b c d

Code	Contents
a	Package Type L: DFN1814-6
b	Serial Number for the R5437/R5438 Series designating input threshold for over-charge detector
c	Designation of Output delay option
d	Designation of version symbols.

R5437 Code List

Code	$V_{DET1}n$(V) *1	$V_{REL1}n$(V) *1	tV_{DET1}(s)
R5437L 301AA	4.450	4.150	2
R5437L 301BA	4.450	4.150	4
R5437L 303AA	4.350	4.050	2
R5437L 303BA	4.350	4.050	4
R5437L 303CA	4.350	4.050	6
R5437L 304AA	4.400	4.100	2
R5437L 304BA	4.400	4.100	4
R5437L 305AA	4.300	4.000	2
R5437L 305BA	4.300	4.000	4
R5437L 306CA	4.450	3.950	6
R5437L 307CA	4.500	4.100	6
R5437L 312AA	4.550	4.150	2
R5437L 312BA	4.550	4.150	4

*1：n＝1, 2, 3

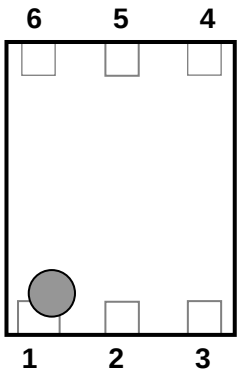
R5438 Code List

Code	$V_{DET1}n(V)$ *1	$V_{REL1}n(V)$ *1	$tV_{DET1}(s)$
R5438L 301AA	4.450	4.150	2
R5438L 301BA	4.450	4.150	4
R5438L 303AA	4.350	4.050	2
R5438L 303BA	4.350	4.050	4
R5438L 304AA	4.400	4.100	2
R5438L 304BA	4.400	4.100	4
R5438L 305AA	4.300	4.000	2
R5438L 305BA	4.300	4.000	4
R5438L 306CA	4.450	3.950	6
R5438L 308BA	4.400	4.000	4
R5438L 312AA	4.550	4.150	2
R5438L 312BA	4.550	4.150	4

*1：n＝1, 2, 3

PIN CONFIGURATIONS

DFN1814-6



PIN DESCRIPTION

R5437

Pin No.	Symbol	Description
1	V_{C1}	Positive terminal pin for Cell-1
2	V_{C2}	Positive terminal pin for Cell-2
3	V_{SS}	V_{SS} pin. Ground pin for the IC
4	V_{C3}	Positive terminal Pin for Cell-3
5	V_{DD}	V_{DD} Pin
6	C_{OUT}	Output pin of over-charge detection

R5438

Pin No.	Symbol	Description
1	C_{OUT}	Output pin of over-charge detection
2	V_{DD}	V_{DD} Pin
3	V_{C1}	Positive terminal pin for Cell-1
4	V_{C2}	Positive terminal pin for Cell-2
5	V_{C3}	Positive terminal Pin for Cell-3
6	V_{SS}	V_{SS} pin. Ground pin for the IC

ABSOLUTE MAXIMUM RATINGS

Ta=25°C, V_{SS}=0V

Symbol	Item	Ratings	Unit
V_{DD}	Supply voltage	V_{C1} -0.3 to V_{C1}+6.5 V_{C1} -0.3 to 26	V
 V_{C1} V_{C2} V_{C3}	Input voltage Positive input pin voltage for Cell-1 Positive input pin voltage for Cell-2 Positive input pin voltage for Cell-3	 V_{C2} -0.3 to V_{C2}+6.5 V_{C3} –0.3 to V_{C3}+6.5 –0.3 to 6.5	V
V_{COUT}	Output voltage C_{OUT} pin voltage	 -0.3 to V_{OH1}+0.3	V
P_D	Power dissipation	150	mW
Ta	Operating temperature range	-40 to 85	°C
Tstg	Storage temperature range	-55 to 125	°C

*Note: Exposure to the condition exceeded Absolute Maximum Ratings may cause the permanent damages and affects the reliability and safety of both device and systems using the device. The functional operations cannot be guaranteed beyond specified values in the recommended conditions.

ELECTRICAL CHARACTERISTICS

Unless otherwise specified, Ta=25°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	Test Circuit
V_{DD1}	Operating input voltage	Voltage defined as V_{DD}-V_{SS}	1.5		20	V	
$V_{DET1}n$	CELLn Over-charge threshold (n=1,2,3)	Detect rising edge of supply voltage (25°C)	$V_{DET1}n$ -0.020	$V_{DET1}n$	$V_{DET1}n$ +0.020	V	A
		Detect rising edge of supply voltage (0 to 60°C) *Note1	$V_{DET1}n$ -0.025		$V_{DET1}n$ +0.025		
$V_{REL1}n$	CELLn Over-charge released voltage (n=1,2,3)	Detect falling edge of supply voltage	$V_{REL1}n$ -0.050	$V_{REL1}n$	$V_{REL1}n$ +0.050	V	A
tV_{DET1}	Output delay of over-charge	$V_{CELL}n$=3.9V, $V_{CELL}1$=3.9V to 4.7V (n=2,3) *Note2	tV_{DET1} ×0.8	tV_{DET1}	tV_{DET1} ×1.2	s	B
tV_{REL1}	Output delay of release from over-charge	$V_{CELL}n$=3.9V, $V_{CELL}1$=4.7V to 3.9V (n=2,3)	tV_{REL1} ×0.8	tV_{REL1}	tV_{REL1} ×1.2	ms	B
V_{SHT}	Shutdown detector threshold	Detect falling edge	3.2	3.5	3.8	V	C
V_{OH1}	C_{OUT} Pch ON voltage1	I_{OH}=0μA, $V_{CELL}n$=4.7V (n=1,2,3)	4.0	4.7	5.4	V	D
		I_{OH}=0μA, $V_{CELL}n$=4.7V (n=1,1cell protection)		VDD			
V_{OH2}	C_{OUT} Pch ON voltage2	I_{OH}=-50μA, $V_{CELL}n$=4.7V (n=1,2,3)	V_{OH1} -0.5	V_{OH1} -0.1		V	E
V_{OL}	C_{OUT} Nch ON voltage	I_{OL}=50μA, $V_{CELL}n$=3.9V (n=1,2,3)		0.1	0.5	V	F
I_{SHT}	Shutdown Current	$V_{CELL}n$=3.1V (n=1,2,3)			0.1	μA	G
I_{SS}	Supply current	$V_{CELL}n$=3.9V (n=1,2,3)		0.85	1.7	μA	G

*Note1: This specification is guaranteed by design, not mass production tested.
*Note2: $V_{CELL}n$ means Cell-n's voltage. n=1, 2, 3

RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)

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 when 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.

Ta=-40 ~ 85°C

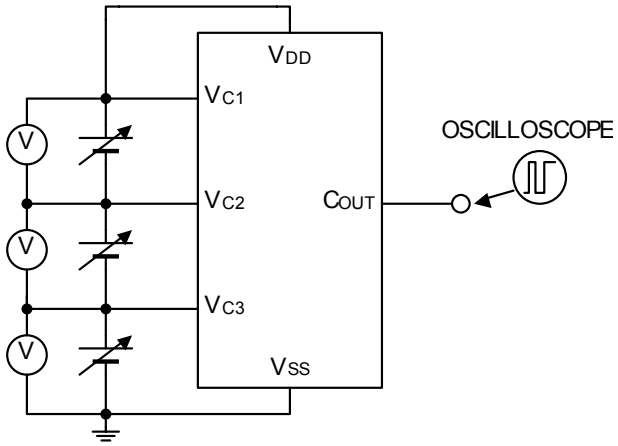
Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	Test Circuit
V_{DD1}	Operating input voltage	Voltage defined as V_{DD}-V_{SS}	1.5		20	V	
$V_{DET1}n$	CELLn Over-charge threshold (n=1,2,3)	Detect rising edge of supply voltage	$V_{DET1}n$ -0.038	$V_{DET1}n$	$V_{DET1}n$ +0.037	V	A
$V_{REL1}n$	CELLn Over-charge released voltage (n=1,2,3)	Detect falling edge of supply voltage	$V_{REL1}n$ -0.069	$V_{REL1}n$	$V_{REL1}n$ +0.067	V	A
tV_{DET1}	Output delay of over-charge	$V_{CELL}n$=3.9V, V_{CELL1}=3.9V to 4.7V (n=2,3) *Note1	tV_{DET1} ×0.54	tV_{DET1}	tV_{DET1} ×1.39	s	B
tV_{REL1}	Output delay of release from over-charge	$V_{CELL}n$=3.9V, V_{CELL1}=4.7V to 3.9V (n=2,3)	tV_{REL1} ×0.54	tV_{REL1}	tV_{REL1} ×1.39	ms	B
V_{SHT}	Shutdown detector threshold	Detect falling edge	3.120	3.5	3.878	V	C
V_{OH1}	C_{OUT} Pch ON voltage1	I_{OH}=0μA, $V_{CELL}n$=4.7V (n=1,2,3)	3.985	4.7	5.441	V	D
		I_{OH}=0μA, $V_{CELL}n$=4.7V (n=1,1cell protection)		VDD			
V_{OH2}	C_{OUT} Pch ON voltage2	I_{OH}=-50μA, $V_{CELL}n$=4.7V (n=1,2,3)	V_{OH1} -0.61	V_{OH1} -0.1		V	E
V_{OL}	C_{OUT} Nch ON voltage	I_{OL}=50μA, $V_{CELL}n$=3.9V (n=1,2,3)		0.1	0.515	V	F
I_{SHT}	Shutdown Current	$V_{CELL}n$=3.1V (n=1,2,3)			0.12	μA	G
I_{SS}	Supply current	$V_{CELL}n$=3.9V (n=1,2,3)		0.85	1.91	μA	G

*Note1: $V_{CELL}n$ means Cell-n's voltage. n=1, 2, 3

Note: All of this specification is guaranteed by design, not mass production tested.

TEST CIRCUITS

A



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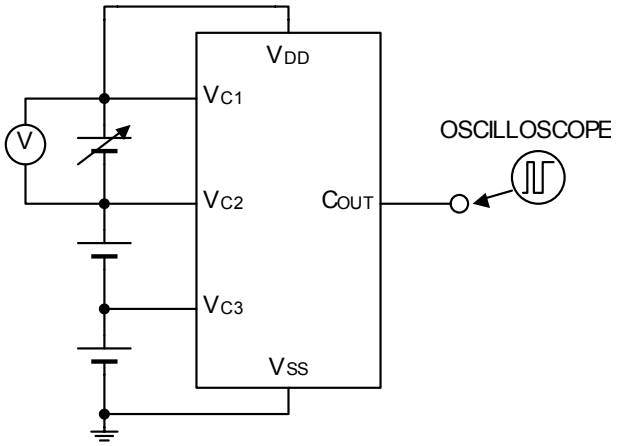

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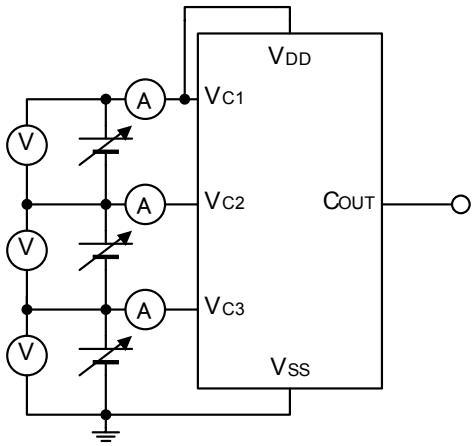

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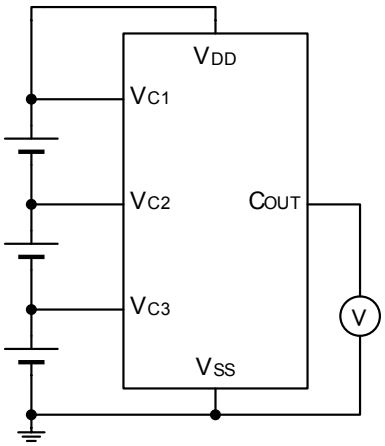

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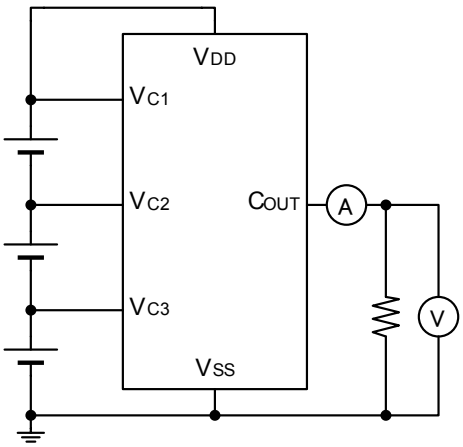

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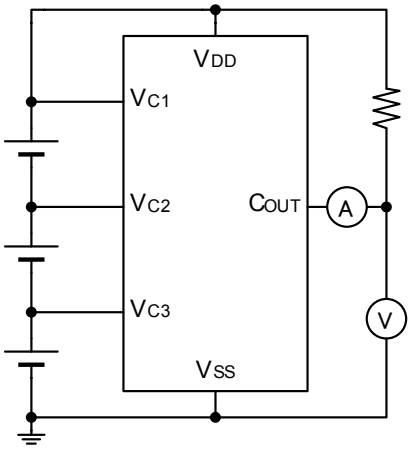

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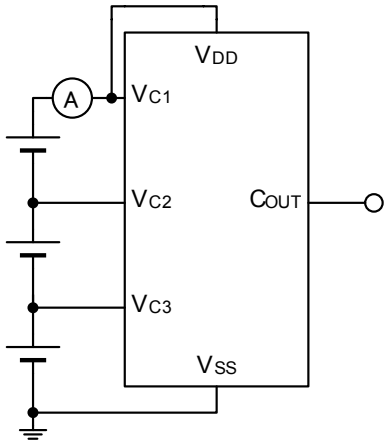


OPERATION

- **VDET1n / Over-Charge Detectors (n=1, 2, 3)**

While the cells are charged, the voltage between V_{C1} pin and V_{C2} pin (voltage of the Cell-1), the voltage between V_{C2} pin and V_{C3} pin (voltage of the Cell-2), and the voltage between V_{C3} pin and V_{ss} pin (voltage of the Cell-3) are supervised. If at least one of the cells' voltage becomes equal or more than the over-charge detector threshold, the over-charge is detected, and an external charge control Nch MOSFET turns on with C_{OUT} pin being at "H" level and by cutting a fuse on the charger path, and charge stops.

To reset the over-charge and make the C_{OUT} 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 over-charge released voltage.

Internal fixed output delay times for over-charge detection and release from over-charge exist. Even if one of voltage of the cells keeps its level more than the over-charge detector threshold, and output delay time passes, over-charge voltage is detected. After detecting over-charge, even if all the cell voltages become equal or less than the released voltage from over-charge, if at least one of the cells voltage becomes higher than the released voltage from over-charge within the output delay time of the release from over-charge, then over-charge is not released.

The output type of the C_{OUT} pin is CMOS output between V_{SS} and the built-in regulator, and "H" level of C_{OUT} pin is the output voltage of the built-in regulator. (Typ. 4.7V)

- **Shutdown Function**

The voltage between V_{C1} pin and V_{C2} pin (the voltage of Cell-1), the voltage between V_{C2} pin and V_{C3} pin (Cell-2 voltage), and the voltage between V_{C3} pin and V_{SS} pin (Cell-3 voltage) are supervised. If all the cells voltages become equal or less than the shutdown detector threshold, all the circuits are halted and shut down, as a result, the consumption current of IC itself (Shutdown current) is extremely reduced. (Max. 0.1μA)

After detecting shutdown, at least one of the cell voltages becomes equal or more than the shutdown detector threshold, the shutdown state is released.

- **DS (Delay Shortening) Function**

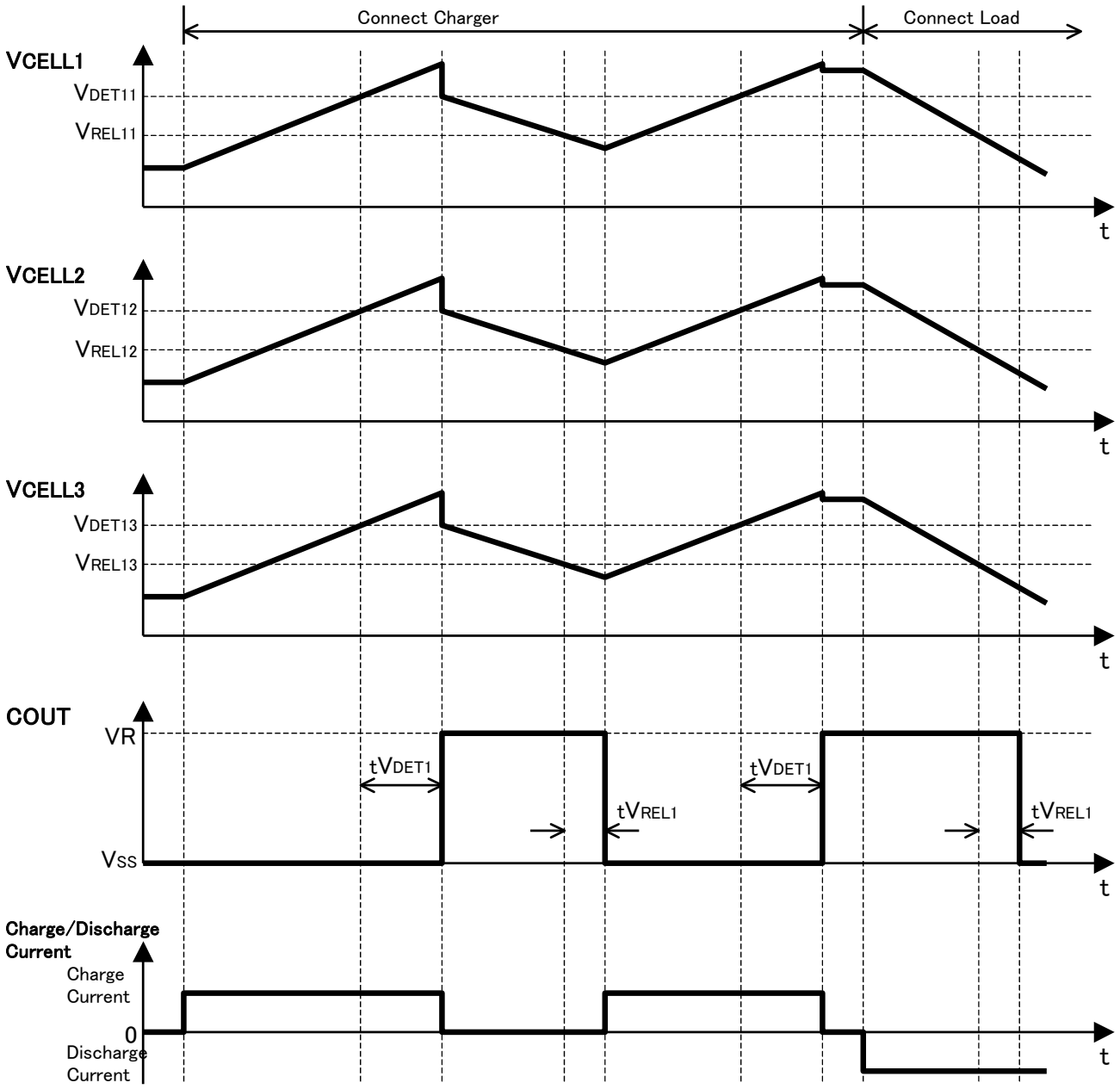
By applying the voltage of 4V±0.2V to VDD-VC1, over-charge delay time can be shortened to about 1/90 and released delay time can be shortened to about 1/60.

- **1-cell/ 2-cell/ 3-cell protection alternative**

When the IC should be used as a 1-cell protection IC, connect short V_{C1} pin – V_{C2} pin and V_{C3} pin - V_{SS} pin.
When the IC should be used as a 2-cell protection IC, connect short V_{C1} pin – V_{C2} pin or V_{C3} pin - V_{SS} pin.

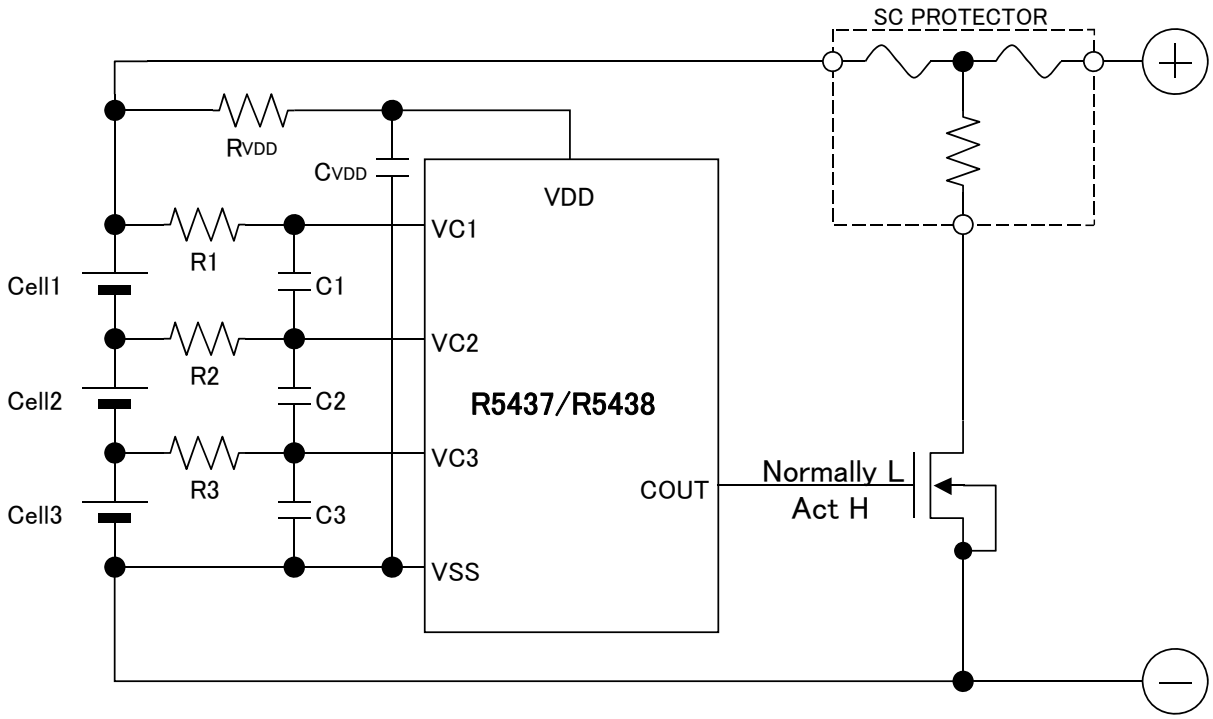
TIMING CHART

●Over-charge operation

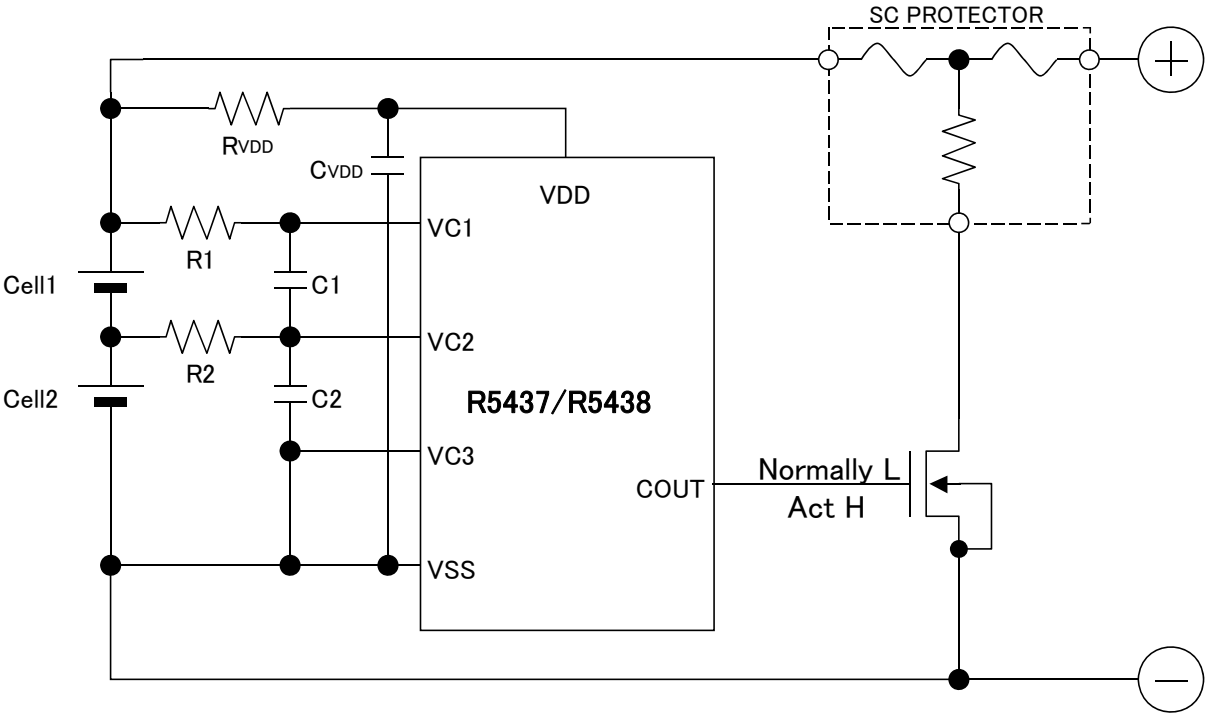


TYPICAL APPLICATIONS

(1) Circuit example (3-cell protection)

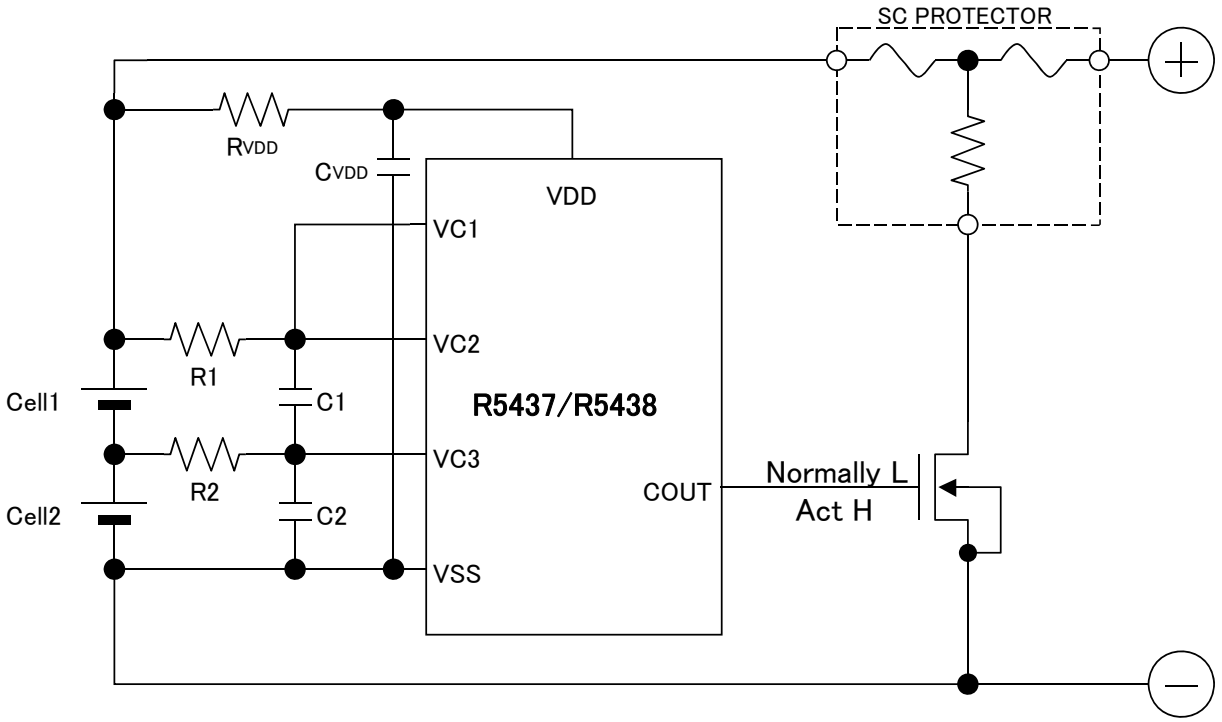


(2-1) Circuit example (2-cell protection 1)

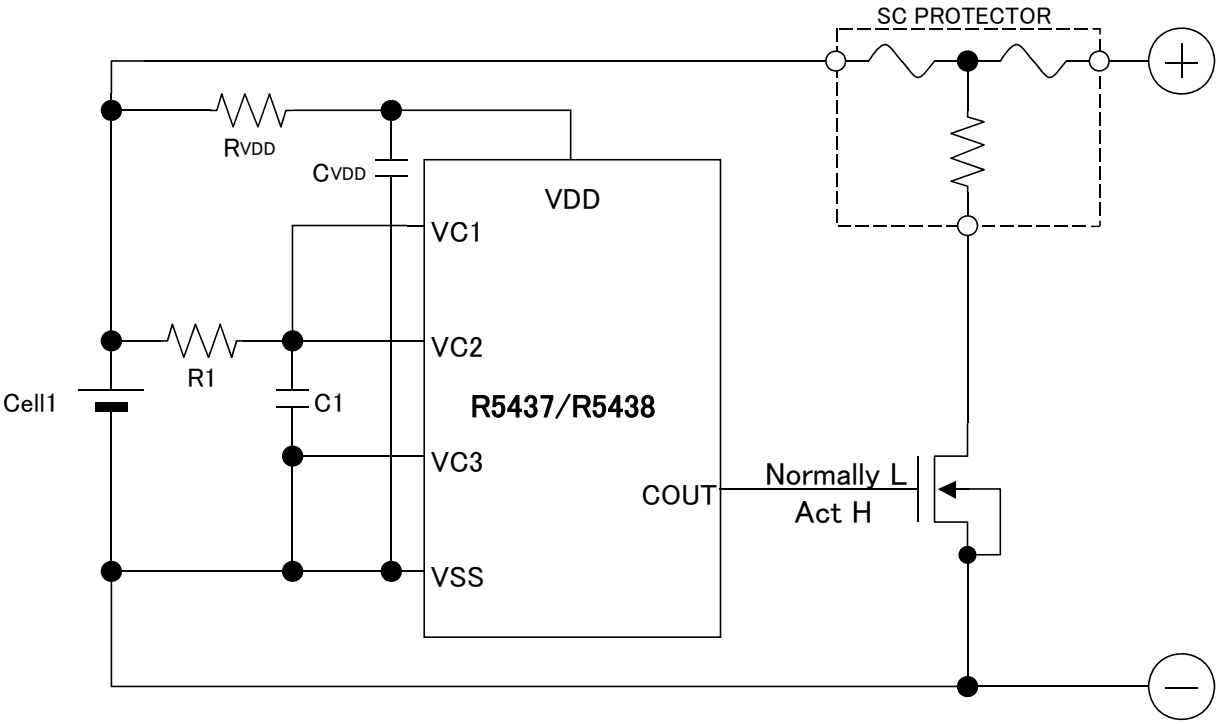


*In terms of the order of connecting cells, the positive terminal of the cell 1 should be the last. Otherwise, COUT may output "H" tentatively, and the fuse may be fused.

(2-2) Circuit example (2-cell protection 2)



(3) Circuit example (1-cell protection)



*In terms of the order of connecting cells, the positive terminal of the cell 1 should be the last. Otherwise, COUT may output "H" tentatively, and the fuse may be fused.

●**External parts ratings**

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

Technical Notes

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 V_{DD} pin and V_{C1} pin is generated, and unexpected operation may result. Therefore, the appropriate value range of R_{VDD} is from 100Ω to 1kΩ. To make a stable operation of the IC, the appropriate value range of C_{VDD} is from 0.01μF to 1.0μF.

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 1kΩ. To make a stable operation of the IC, the appropriate value range of C1 to C3 is 0.01μF 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.

Over-voltage 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 over-charge, a large current may flow through the FET. Select an FET with large enough current capacity in order to endure the large current.

Ricoh cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Ricoh product. If technical notes are not complied with the circuit which is used Ricoh product, Ricoh is not responsible for any damages and any accidents.

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

*SC protector

Contact: Dexerials Corporation (Sony Chemical & Information Device Company Ltd.)
Zip code 141-0032

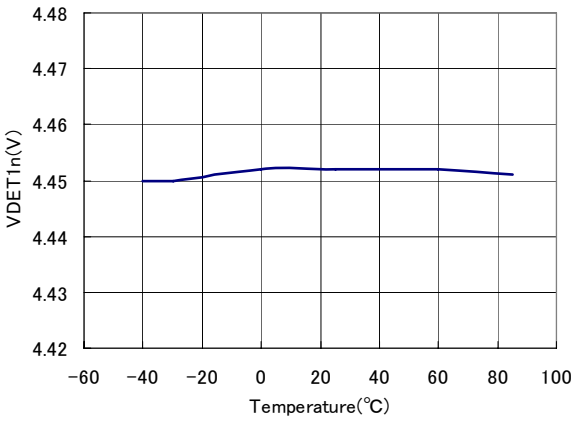
1-11-2 Osaki, Shinagawa, Tokyo
Gate-city Osaki East Tower 8F
Phone 03-5435-3946
http://www.dexerials.jp

TYPICAL CHARACTERISTICS

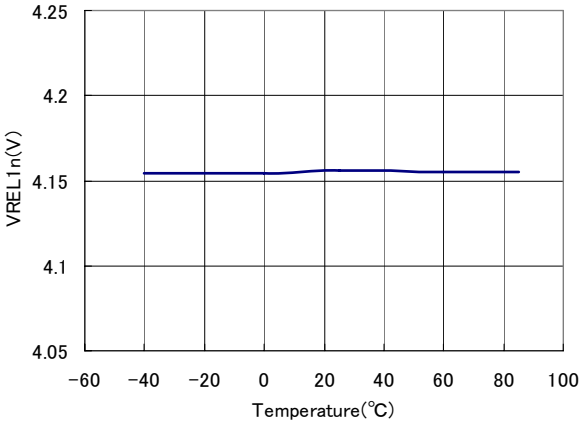
- **Part 1. vs. Temperature**

1)Celln over-charge detector threshold vs. Temperature 2)Celln Over-charge released voltage vs. Temperature

R5438L301AA
V_{CELLn}=3.9V(n=1,2,3)

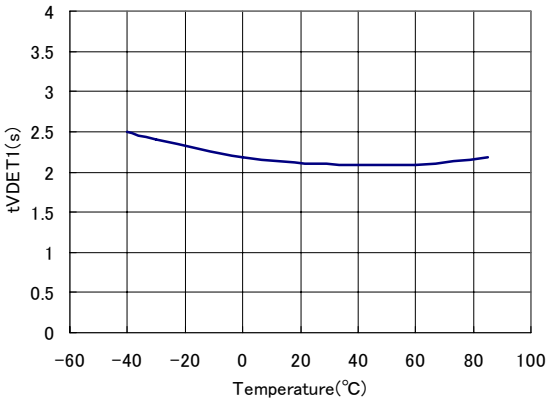


R5438L301AA
V_{CELLn}=3.9V(n=1,2,3)

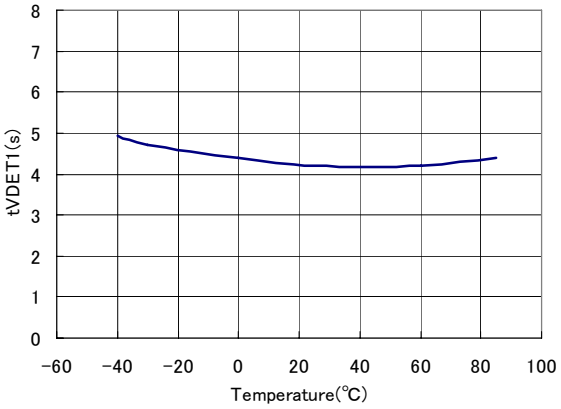


3) Over-charge output delay time vs. Temperature

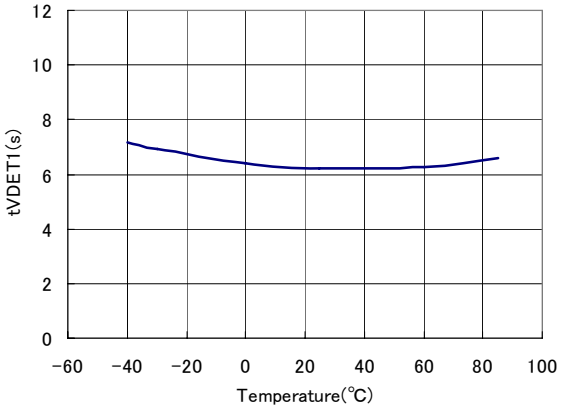
R5438L301AA
VCELLn=3.9V(n=2,3). $V_{CELL}1$=3.9V→4.7V



R5437L304BA
VCELLn=3.9V(n=2,3). $V_{CELL}1$=3.9V→4.7V



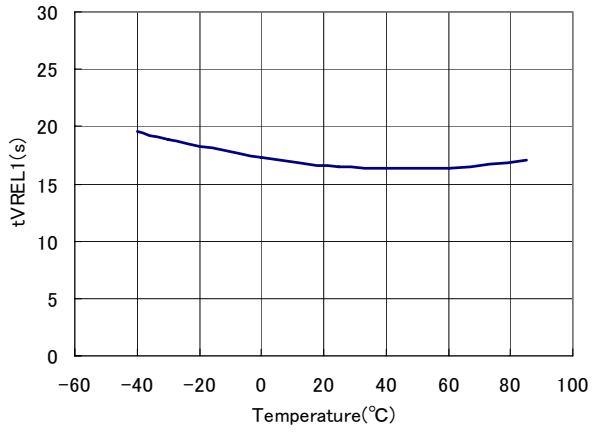
R5437L306CA
VCELLn=3.9V(n=2,3). $V_{CELL}1$=3.9V→4.7V



4) Released delay time from over-charge vs. Temperature

R5438L301AA

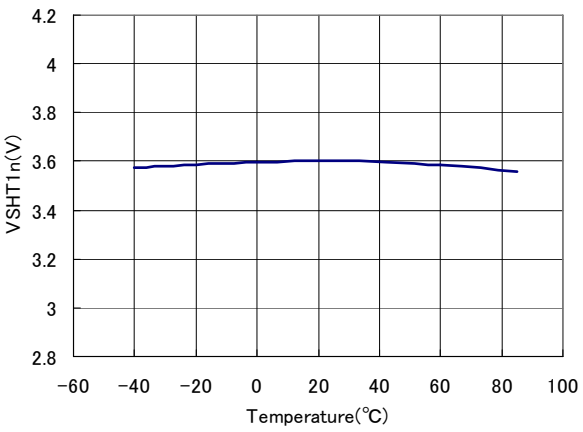
VCELLn=3.9V(n=2,3). $V_{CELL}1$=4.7V→3.9V



5) Celln shutdown threshold vs. Temperature

R5438L301AA

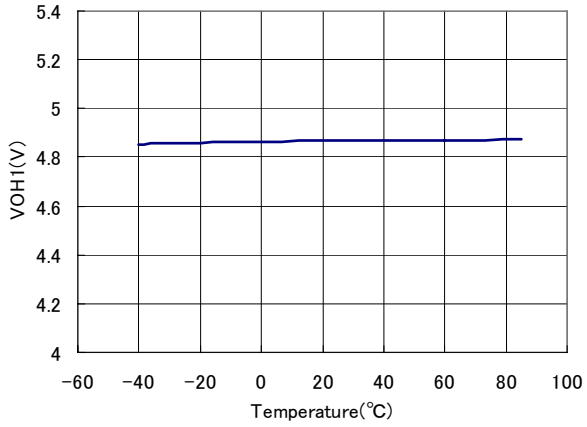
V_{CELLn}=3.1V(n=1,2,3)



6) COUT P-channel On voltage (No Load)vs. Temperature

R5438L301AA

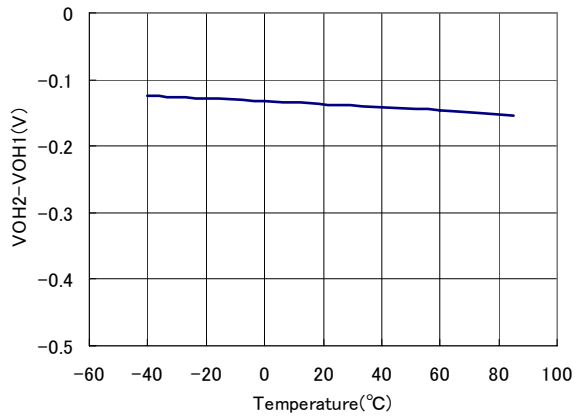
V_{CELLn}=4.7V(n=1,2,3),I_{OH}=0uA



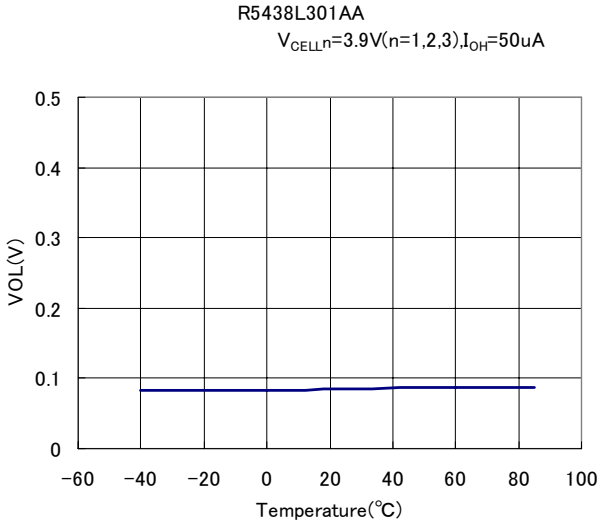
7) COUT P-channel On voltage vs. Temperature

R5438L301AA

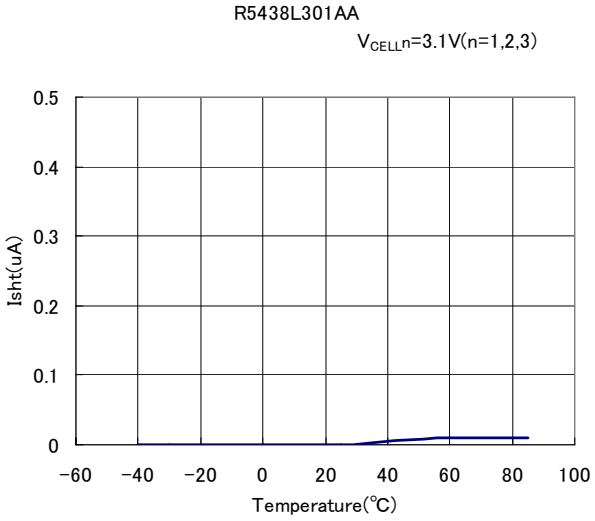
V_{CELLn}=4.7V(n=1,2,3),I_{OH}=−50uA



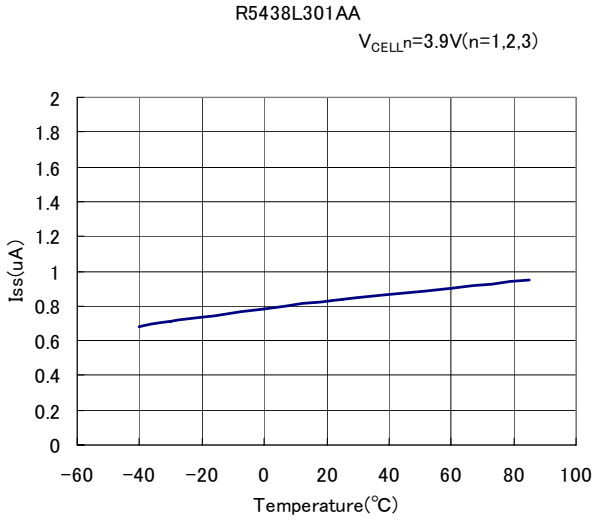
8) COUT N-channel On voltage vs. Temperature



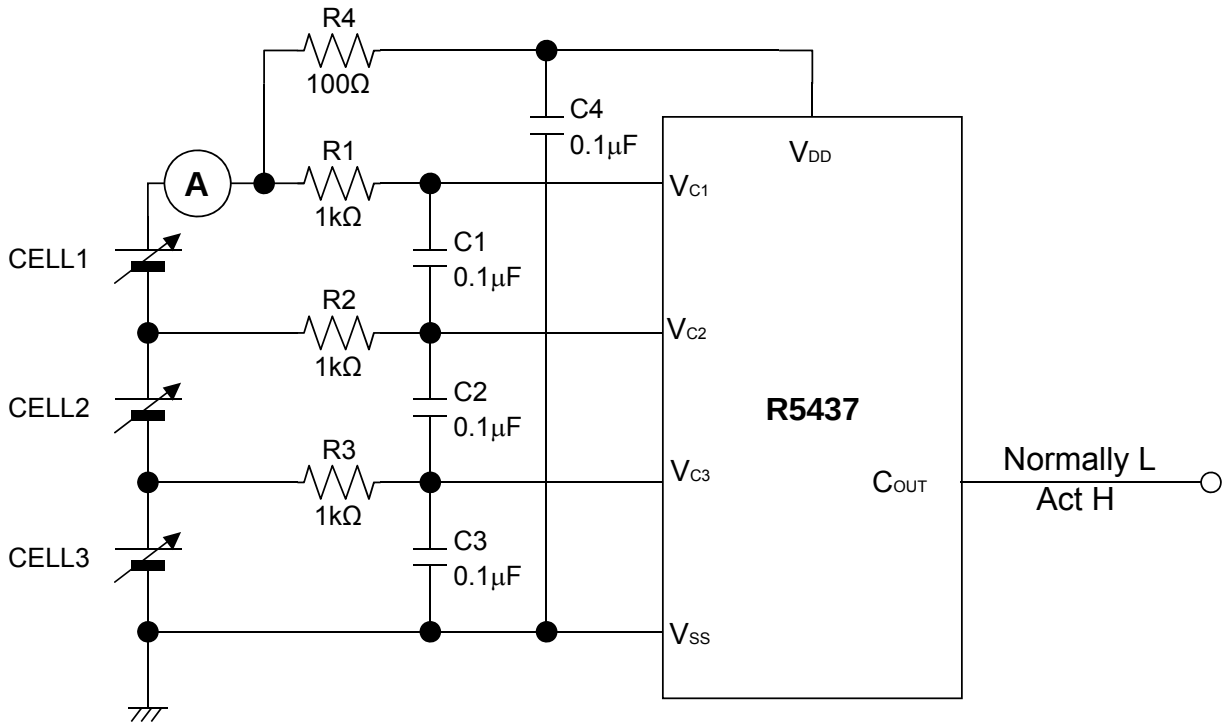
9) Shutdown Current vs. Temperature



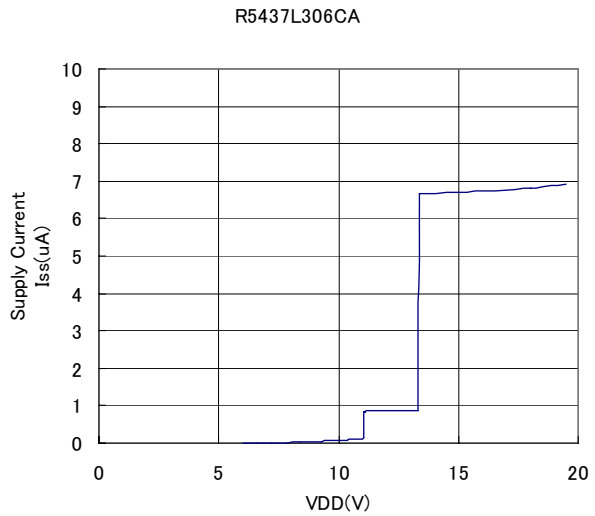
10) Supply Current vs. Temperature



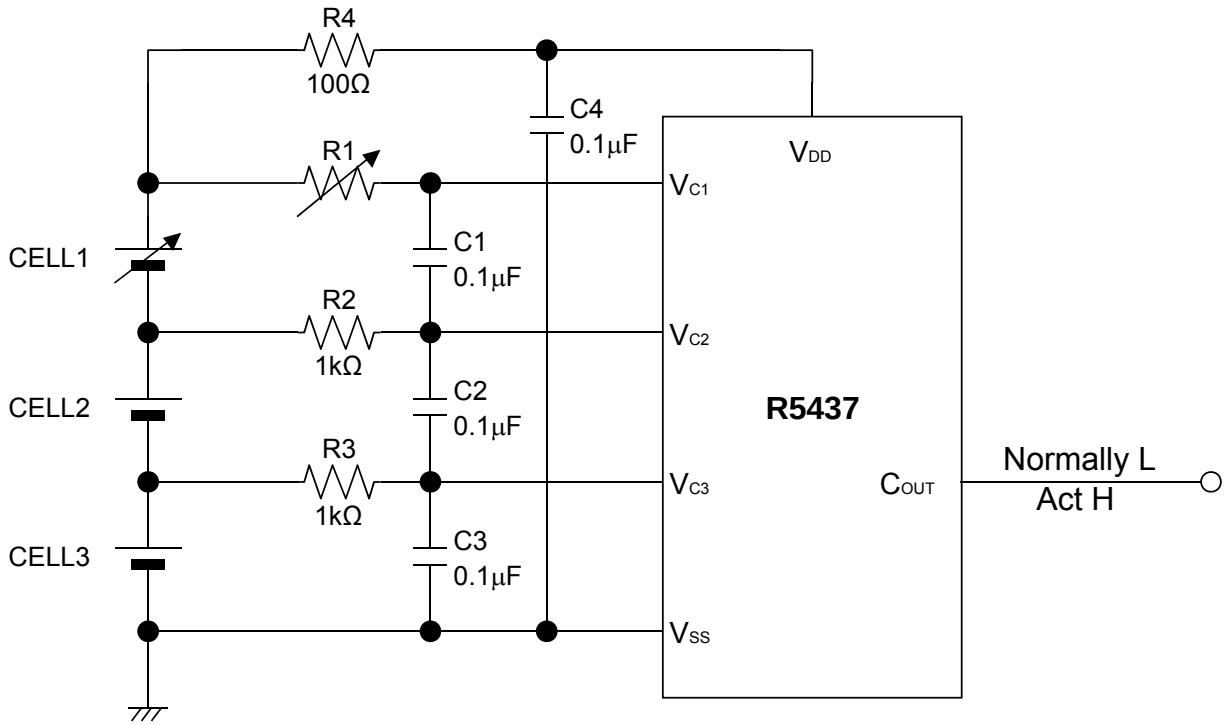
Part2. Supply Current vs. V_{DD} (R5437L306CA)



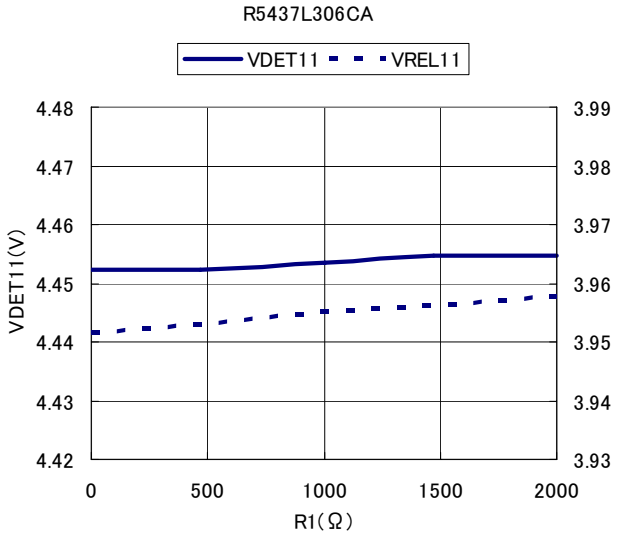
●3-cell protection Supply current vs. V_{DD}



Part3. vs. External Resister dependence (R5437L306CA)



●Overcharge detector threshold/ Over-charge released voltage vs. R1



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