

## 2 to 4 Serial Cell Li-Ion or Li-Polymer Battery Protection IC for Secondary Protection

NO.EA-349-240626

### OUTLINE

The R5439K is an overcharge protection IC for 2 to 4 serial cell Li-ion or Li-polymer secondary battery. Internally, the R5439K consists of high-accuracy voltage detection circuit, a delay circuit, and a voltage regulator for operating the external real-time clock. The two-stage shut-down detection circuit can reduce the supply current to the minimum.

### FEATURES

- High Voltage Tolerant Process  
Absolute Maximum Ratings ..... 32 V
- Low Supply Current  
During Operation, Cell-voltage: 4.15 V, 4-Cells ..... Typ. 4.0  $\mu$ A  
Shutdown 1 ..... Typ. 2.5  $\mu$ A  
Shutdown 2 (Standby) ..... Max. 0.2  $\mu$ A
- Output Voltage  
Built-in Regulator ..... 2.9 V to 3.7 V, 0.1 V step  
Output Voltage Accuracy .....  $\pm 2\%$   
COUT Output (CMOS Output, Active-high) ..... Typ. 4.7 V
- High-accuracy Voltage Detection  
Overcharge Detector Threshold ( $V_{DET1n}^{(1)}$ ) ..... 4.20 V to 4.65 V, in 5 mV step  
Overcharge Detector Threshold Accuracy .....  $\pm 0.02$  V ( $T_a = 25^\circ\text{C}$ )  
.....  $\pm 0.025$  V ( $0^\circ\text{C} < T_a < 60^\circ\text{C}$ )  
Overcharge Release Voltage ( $V_{REL1n}^{(1)}$ ) .....  $V_{DET1n} - 0\text{V}$  to  $V_{DET1n} - 0.4\text{V}$ , in 50 mV step  
..... Min. 4.15V  
Overcharge Detection Delay Time ..... 2-, 4-, or 6-sec with Delay Time Shortening Function<sup>(2)</sup>  
Overcharge Release Voltage Condition ..... Voltage Release Type
- Shutdown Functions  
[Shutdown 1]  
Shutdown 1 Detector Threshold ..... Typ. 3.8 V,  $\pm 0.3$  V  
Shutdown 1 Detection Delay Time ..... none  
[Shutdown 2]  
Shutdown 2 Detector Threshold ( $V_{SHT2n}^{(1)}$ ) ..... 2.3 V to 2.8 V, 100 mV step  
Shutdown 2 Detector Threshold Accuracy .....  $\pm 0.05$  V  
Shutdown 2 Release Voltage .....  $V_{SHT2n} + 0.2$  V  
Shutdown 2 Detection Delay Time ..... 2-, 4-, or 6-sec
- 2 to 4 Cells Selectable Battery Protection
- Timer Reset Delay Function
- Compact Package  
DFN (PL) 2020-8 ..... 2.0 mm x 2.0 mm

<sup>(1)</sup>  $V_{DET1n}$ ,  $V_{REL1n}$ ,  $V_{SHT2n}$  :  $n = 1, 2, 3, 4$

<sup>(2)</sup> The delay time can be reduced down to approx. 1/80 by applying a 4 V  $\pm$  0.2 V to the VDD – VC1 pins.

## APPLICATIONS

- Li-Ion or Li-Polymer Battery Protection

## SELECTION GUIDE

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

### Selection Guide

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R5439Kxxx\$*-TR	DFN (PL) 2020-8	5,000 pcs	Yes	Yes

xxx: Specify the combination of the overcharge detector threshold ( $V_{DET1n}$ ), the overcharge release voltage ( $V_{REL1n}$ ), the shutdown 2 detector threshold ( $V_{SHT2n}$ ) and the voltage regulator output voltage ( $V_{ROUT}$ )<sup>(1)</sup>.

$V_{DET1n}$ <sup>(2)</sup>: 4.20 V to 4.65 V in 5 mV step

$V_{REL1n}$ <sup>(2)</sup>:  $V_{DET1n} - 0$  V to  $V_{DET1n} - 0.4$  V in 50 mV step, Min. 4.15 V

$V_{SHT2n}$ <sup>(2)</sup>: 2.3 V to 2.8 V in 100 mV step

$V_{ROUT}$ : 2.9 V to 3.7 V in 0.1 V step

\$: Specify the combination of the overcharge detection delay time ( $t_{VDET1}$ ), the shutdown 2 detection delay time ( $t_{VSHT2}$ ) and the overcharge release delay time ( $t_{VREL1}$ ) and the overcharge detection timer reset delay time ( $t_{VTR}$ ). Refer to *Delay Time Code Table* for details.

**Delay Time Code Table**

Code	$t_{VDET1}$ (s)	$t_{VSHT2}$ (s)	$t_{VREL1}$ (ms)	$t_{VTR}$ (ms)
A	2	2	16	6
B	4	2	16	6
C	6	2	16	6
D	2	4	16	6
E	4	4	16	6
F	6	4	16	6
G	2	6	16	6
H	4	6	16	6
J	6	6	16	6
K	1.5	4.5	12	4.5

\*: Specify the timer reset delay time option. Refer to *Timer Reset Delay Time Table* for details.

**Timer Reset Delay Time Table**

Code	Timer Reset Delay Time
A	No
B	Yes

<sup>(1)</sup> Refer to *Product Code Table* for details.

<sup>(2)</sup>  $V_{DET1n}$ ,  $V_{REL1n}$ ,  $V_{SHT2n}$ : n = 1, 2, 3, 4

## ● Product Code List

The product code is determined by the combination of the set output voltage (overcharge detector threshold:  $V_{DET1n}$ , overcharge release voltage:  $V_{REL1n}$ , shutdown 2 detector threshold:  $V_{SHT2n}$ , voltage regulator output voltage:  $V_{ROUT}$ ) and the delay time (overcharge detection delay time:  $t_{VDET1}$ , shutdown 2 detection delay time:  $t_{VSHT2}$ , overcharge release delay time:  $t_{VREL1}$ , overcharge detection timer reset delay time:  $t_{VTR}$ ) and the timer reset delay time option ( $t_{VTR}$ ).

Product Code Table

Product Name	Set Output Voltage (V)				Delay Time				Timer Reset Delay Time (Yes/No <sup>(1)</sup> )
	$V_{DET1n}$	$V_{REL1n}$	$V_{SHT2n}$	$V_{ROUT}$	$t_{VDET1}$ (s)	$t_{VSHT2}$ (s)	$t_{VREL1}$ (ms)	$t_{VTR}$ (ms)	
R5439K213HA	4.450	4.250	2.500	2.900	4	6	16	—	No
R5439K301GA	4.450	4.150	2.500	3.300	2	6	16	—	No
R5439K301HA	4.450	4.150	2.500	3.300	4	6	16	—	No
R5439K309GA	4.300	4.150	2.500	3.300	2	6	16	—	No
R5439K309HA	4.300	4.150	2.500	3.300	4	6	16	—	No
R5439K310GA	4.350	4.150	2.500	3.300	2	6	16	—	No
R5439K310HA	4.350	4.150	2.500	3.300	4	6	16	—	No
R5439K310KA	4.350	4.150	2.500	3.300	1.5	4.5	12	—	No
R5439K310JB	4.350	4.150	2.500	3.300	6	6	16	6	Yes
R5439K311GA	4.400	4.150	2.500	3.300	2	6	16	—	No
R5439K311HA	4.400	4.150	2.500	3.300	4	6	16	—	No
R5439K312GA	4.550	4.150	2.500	3.300	2	6	16	—	No
R5439K312HA	4.550	4.150	2.500	3.300	4	6	16	—	No
R5439K313JB	4.450	4.250	2.500	3.300	6	6	16	6	Yes
R5439K313KA	4.450	4.250	2.500	3.300	1.5	4.5	12	—	No
R5439K314JB	4.500	4.300	2.500	3.300	6	6	16	6	Yes
R5439K314HA	4.500	4.300	2.500	3.300	4	6	16	—	No
R5439K314KA	4.500	4.300	2.500	3.300	1.5	4.5	12	—	No
R5439K316JB	4.400	4.200	2.500	3.300	6	6	16	6	Yes
R5439K316KA	4.400	4.200	2.500	3.300	1.5	4.5	12	—	No
R5439K317JB	4.500	4.200	2.500	3.300	6	6	16	6	Yes
R5439K318KA	4.325	4.150	2.500	3.300	1.5	4.5	12	—	No
R5439K319JB	4.550	4.350	2.500	3.300	6	6	16	6	Yes
R5439K320KA	4.500	4.300	2.500	3.100	1.5	4.5	12	—	No
R5439K321KA	4.500	4.300	2.500	3.200	1.5	4.5	12	—	No
R5439K323JB	4.550	4.250	2.500	3.000	6	6	16	6	Yes
R5439K324JB	4.500	4.200	2.500	3.000	6	6	16	6	Yes
R5439K325JB	4.500	4.300	2.800	3.300	6	6	16	6	Yes
R5439K326JB	4.220	4.150	2.500	3.300	6	6	16	6	Yes
R5439K327JB	4.600	4.300	2.500	3.000	6	6	16	6	Yes
R5439K328JB	4.600	4.300	2.500	3.300	6	6	16	6	Yes

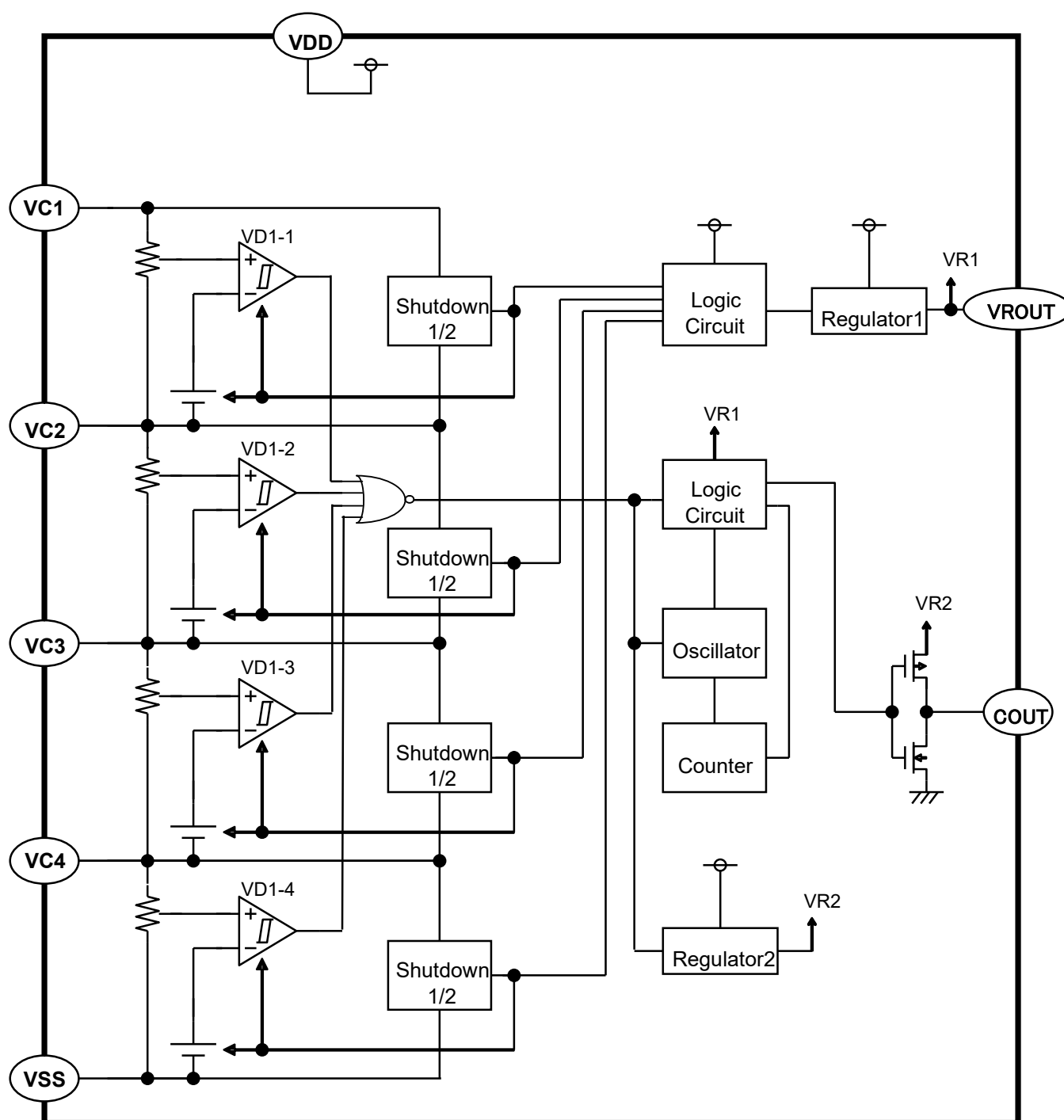
<sup>(1)</sup> "No" means the timer reset delay time option is absence.

Product Code Table (Continued)

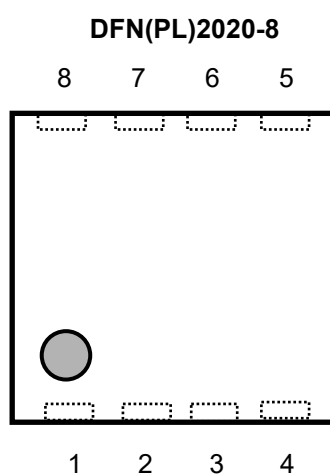
Product Name	Set Output Voltage (V)				Delay Time				Timer Reset Delay Time (Yes/No <sup>(1)</sup> )
	V <sub>DET1n</sub>	V <sub>REL1n</sub>	V <sub>SHT2n</sub>	V <sub>ROUT</sub>	t <sub>VDET1</sub> (s)	t <sub>VSHT2</sub> (s)	t <sub>VREL1</sub> (ms)	t <sub>VTR</sub> (ms)	
R5439K314JA	4.500	4.300	2.500	3.300	6	6	16	—	No
R5439K317JA	4.500	4.200	2.500	3.300	6	6	16	—	No
R5439K319JA	4.550	4.350	2.500	3.300	6	6	16	—	No
R5439K323JA	4.550	4.250	2.500	3.000	6	6	16	—	No
R5439K324JA	4.500	4.200	2.500	3.000	6	6	16	—	No
R5439K327JA	4.600	4.300	2.500	3.000	6	6	16	—	No
R5439K328JA	4.600	4.300	2.500	3.300	6	6	16	—	No
R5439K329JA	4.550	4.250	2.500	3.300	6	6	16	—	No
R5439K330JA	4.550	4.250	2.800	3.300	6	6	16	—	No
R5439K331JA	4.600	4.300	2.800	3.300	6	6	16	—	No
R5439K332JA	4.450	4.150	2.800	3.300	6	6	16	—	No
R5439K333JA	4.450	4.150	2.500	3.000	6	6	16	—	No
R5439K334JA	4.650	4.350	2.500	3.300	6	6	16	—	No
R5439K335JA	4.650	4.350	2.500	3.000	6	6	16	—	No

<sup>(1)</sup> "No" means the timer reset delay time option is absence.

## BLOCK DIAGRAM



## PIN DESCRIPTIONS



**DFN(PL)2020-8 Pin Description**

Pin No.	Symbol	Description
1	VDD	Power Supply Pin
2	VC1	CELL1 Plus Pin
3	VC2	CELL2 Plus Pin
4	VC3	CELL3 Plus Pin
5	VC4	CELL4 Plus Pin
6	VSS	IC Ground Pin
7	COUT	Overcharge Detection Output Pin
8	VR0UT	Voltage Regulator Output Pin

## ABSOLUTE MAXIMUM RATINGS

### Absolute Maximum Ratings

(Ta = 25°C, V<sub>SS</sub> = 0 V)

Symbol	Item	Rating	Unit
V <sub>DD</sub>	Power Supply Voltage	V <sub>C1</sub> – 0.3 to V <sub>C1</sub> + 6.5 V <sub>C1</sub> – 0.3 to 32	V
V <sub>C1</sub>	CELL1 Plus Pin Input Voltage	V <sub>C2</sub> – 0.3 to V <sub>C2</sub> + 6.5	V
V <sub>C2</sub>	CELL2 Plus Pin Input Voltage	V <sub>C3</sub> – 0.3 to V <sub>C3</sub> + 6.5	V
V <sub>C3</sub>	CELL3 Plus Pin Input Voltage	V <sub>C4</sub> – 0.3 to V <sub>C4</sub> + 6.5	V
V <sub>C4</sub>	CELL4 Plus Pin Input Voltage	–0.3 to 6.5	V
V <sub>COUT</sub>	COUT Pin Output Voltage	–0.3 to V <sub>OH1</sub> + 0.3	V
V <sub>ROUT</sub>	VR Output Voltage	–0.3 to 6.5	V
I <sub>OUT</sub>	VR Output Current	3	mA
P <sub>D</sub>	Power Dissipation	Refer to Appendix “Power Dissipation”.	
T <sub>j</sub>	Junction Temperature Range	–40 to 125	°C
T <sub>stg</sub>	Storage Temperature Range	–55 to 125	°C

### ABSOLUTE MAXIMUM RATINGS

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages 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 <sub>DD</sub>	Operating Input Voltage	4.0 to 25 / V <sub>C1</sub> + 5.0	V
V <sub>C1</sub>	CELL1 Plus Pin Input Voltage	V <sub>C2</sub> + 1.2 to V <sub>C2</sub> + 5.0	V
	(in 2-/3-cell mode)	V <sub>C2</sub> + 0.0	
V <sub>C2</sub>	CELL2 Plus Pin Input Voltage	V <sub>C3</sub> + 1.2 to V <sub>C3</sub> + 5.0	V
	(in 2-cell mode)	V <sub>C3</sub> + 0.0	
V <sub>C3</sub>	CELL3 Plus Pin Input Voltage	V <sub>C4</sub> + 1.2 to V <sub>C4</sub> + 5.0	V
V <sub>C4</sub>	CELL4 Plus Pin Input Voltage	V <sub>SS</sub> + 1.2 to V <sub>SS</sub> + 5.0	V
T <sub>a</sub>	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.

## ELECTRICAL CHARACTERISTICS

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

$n = 1, 2, 3, 4$ , unless otherwise noted

The specifications surrounded by   are guaranteed by Design Engineering at  $0^{\circ}\text{C} \leq T_a \leq 60^{\circ}\text{C}$ .

### R5439K Electrical Characteristics

( $T_a = 25^{\circ}\text{C}$ )

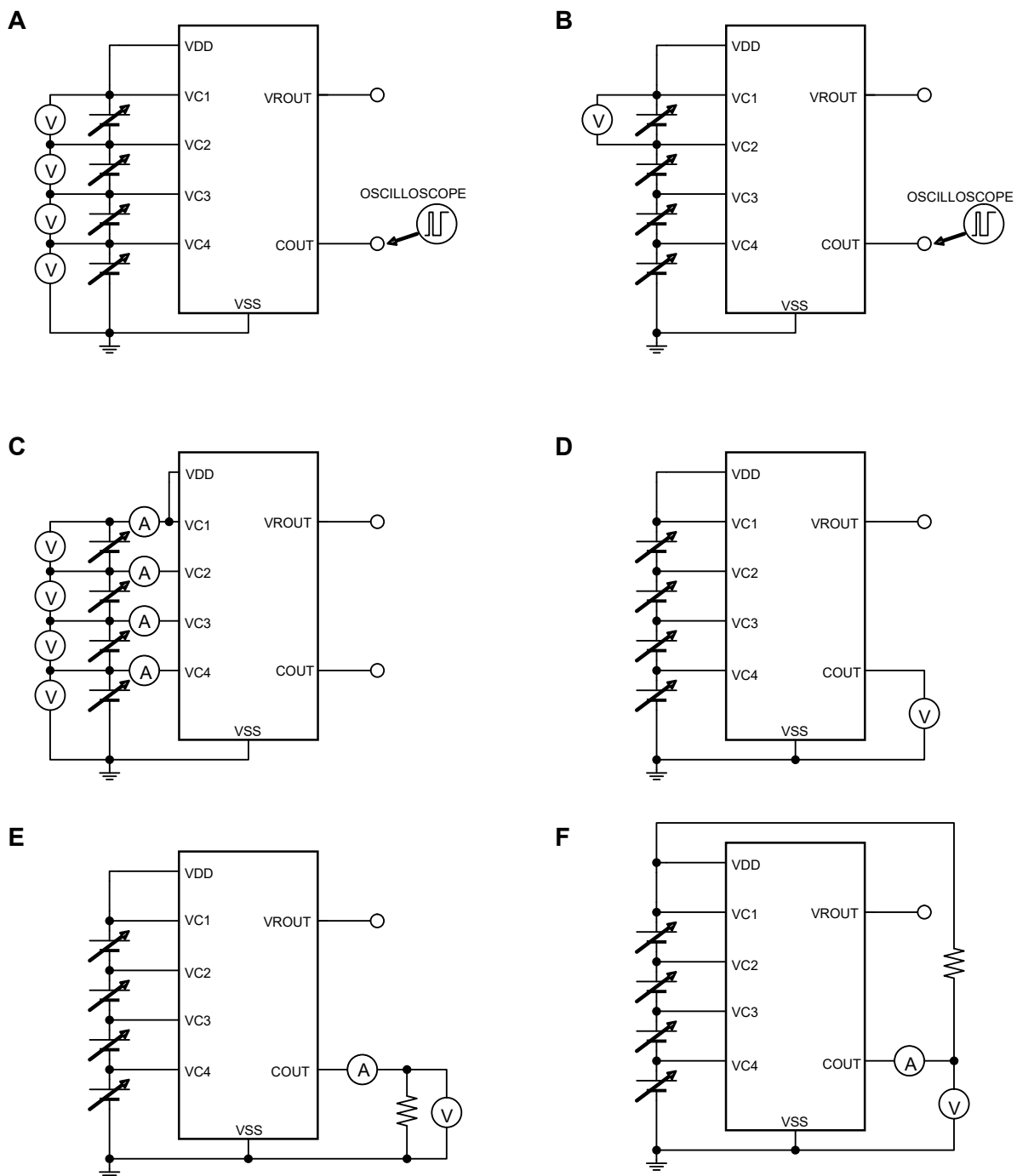
Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	Circuit (1)
$V_{DET1n}$	CELLn Overcharge Detection Threshold	It detects rising edge of supply voltage.	$V_{DET1n}$ -0.020V <span style="border: 1px solid black; padding: 0 2px;">-0.025V</span>	$V_{DET1n}$	$V_{DET1n}$ +0.020V <span style="border: 1px solid black; padding: 0 2px;">+0.025V</span>	V	A
$V_{REL1n}$	CELLn Overcharge Release Voltage	It detects falling edge of supply voltage.	$V_{REL1n}$ -0.050V	$V_{REL1n}$	$V_{REL1n}$ +0.050V	V	A
$t_{VDET1}$	Overcharge Detection Delay Time	$V_{CELLn} = 4.15\text{ V}$ ( $n = 2, 3, 4$ ) $V_{CELL1} = 4.15\text{ V} \rightarrow 4.7\text{ V}$	$t_{VDET1}$ $\times 0.8$	$t_{VDET1}$	$t_{VDET1}$ $\times 1.2$	s	B
$t_{VREL1}$	Overcharge Release Delay Time	$V_{CELLn} = 3.9\text{ V}$ ( $n = 2, 3, 4$ ) $V_{CELL1} = 4.7\text{ V} \rightarrow 3.9\text{ V}$	$t_{VREL1}$ $\times 0.8$	$t_{VREL1}$	$t_{VREL1}$ $\times 1.2$	ms	B
$t_{VTR}$	Overcharge Detection Timer Reset Delay Time (For the Timer Reset Delay function type only)	$V_{CELLn} = V_{DET1n} + 0.05\text{ V}$ $\rightarrow V_{REL1n} - 0.10\text{ V}$ $\rightarrow V_{DET1n} + 0.05\text{ V}$ $\rightarrow V_{REL1n} - 0.10\text{ V}$	2 1.5 <sup>(2)</sup>	6 4.5 <sup>(2)</sup>	10 7.5 <sup>(2)</sup>	ms	B
$V_{SHT1n}$	Shutdown 1 Detector Threshold	It detects falling edge of supply voltage.	3.5	3.8	4.1	V	C
$V_{SHT2n}$	Shutdown 2 Detector Threshold	It detects falling edge of supply voltage.	$V_{SHT2n}$ -0.050V	$V_{SHT2n}$	$V_{SHT2n}$ +0.050V	V	I
$V_{REL2n}$	Shutdown 2 Release Voltage	It detects rising edge of supply voltage.	$V_{REL2n}$ -0.100V	$V_{REL2n}$ ( $V_{SHT2n} + 0.2\text{ V}$ )	$V_{REL2n}$ +0.100V	V	I
$t_{VSHT2}$	Shutdown 2 Detector Delay Time	$V_{CELLn} = V_{SHT2n} - 0.2\text{ V}$ ( $n = 2, 3, 4$ ) $V_{CELL1} = 3.2\text{ V} \rightarrow V_{SHT2n} - 0.2\text{ V}$	$t_{VSHT2}$ $\times 0.8$	$t_{VSHT2}$	$t_{VSHT2}$ $\times 1.2$	s	J
$V_{OL}$	C <sub>OUT</sub> Nch ON Voltage	$I_{OL} = 50\text{ }\mu\text{A}$ , $V_{CELLn} = 4.15\text{ V}$ ( $n = 1, 2, 3, 4$ )		0.1	0.5	V	F
$V_{OH1}$	C <sub>OUT</sub> Pch ON Voltage 1	$I_{OH} = 0\text{ }\mu\text{A}$ , $V_{CELLn} = 4.7\text{ V}$	4.0	4.7	5.4	V	D
$V_{OH2}$	C <sub>OUT</sub> Pch ON Voltage 2	$I_{OH} = -50\text{ }\mu\text{A}$ , $V_{CELLn} = 4.7\text{ V}$	$V_{OH1}$ -0.5V	$V_{OH1}$ -0.1V		V	E
$I_{SHT1}$	Shutdown 1 Current	$V_{CELLn} = 3.1\text{ V}$		2.5	5.75	$\mu\text{A}$	G
$I_{SHT2}$	Shutdown 2 Current	$V_{CELLn} = 2.0\text{ V}$			0.2	$\mu\text{A}$	G
$I_{SS}$	Supply Current	$V_{CELLn} = 4.15\text{ V}$		4.0	7.5	$\mu\text{A}$	G
$I_{VDD}$	VDD Pin Current	$V_{CELLn} = 4.15\text{ V}$		2.4	5.2	$\mu\text{A}$	K
$I_{VC1}$	VC1 Pin Current	$V_{CELLn} = 4.15\text{ V}$		1.6	2.8	$\mu\text{A}$	K
$I_{VC2}$	VC2 Pin Current	$V_{CELLn} = 4.15\text{ V}$	-0.3		0.3	$\mu\text{A}$	K
$I_{VC3}$	VC3 Pin Current	$V_{CELLn} = 4.15\text{ V}$	-0.3		0.3	$\mu\text{A}$	K
$I_{VC4}$	VC4 Pin Current	$V_{CELLn} = 4.15\text{ V}$	-0.3		0.3	$\mu\text{A}$	K
$V_{ROUT}$	VR Output Voltage	$V_{SHT2n} \times 2 + 0.1\text{ V} \leq V_{DD} \leq 25\text{ V}$ , $I_{OUT} = 10\text{ }\mu\text{A}$	$V_{ROUT}$ $\times 0.98$	$V_{ROUT}$	$V_{ROUT}$ $\times 1.02$	V	H
$I_{OUT}$	VR Output Current	$V_{SHT2n} \times 2 + 0.1\text{ V} \leq V_{DD} \leq 25\text{ V}$			2	mA	H

<sup>(1)</sup> Refer to *TEST CIRCUITS* for detail information.

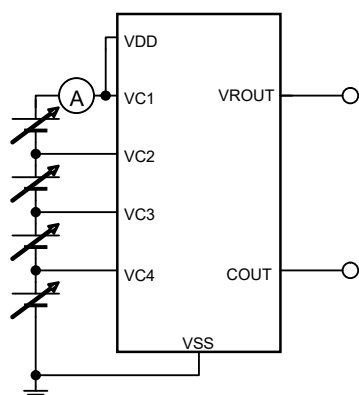
<sup>(2)</sup> The delay time code is K only.



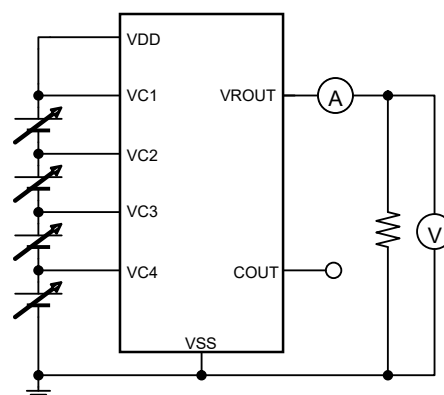
## TEST CIRCUITS



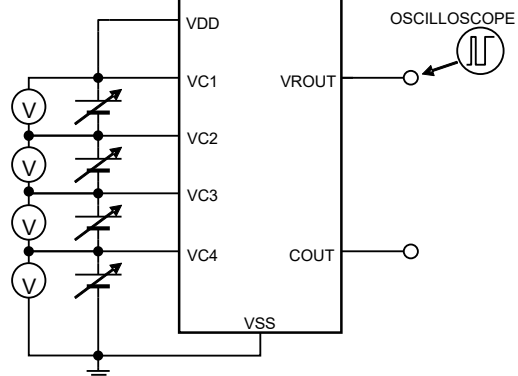
G



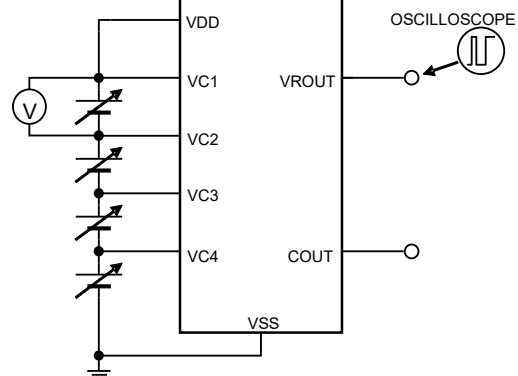
H



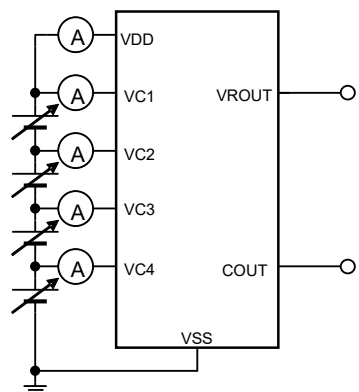
I



J



K



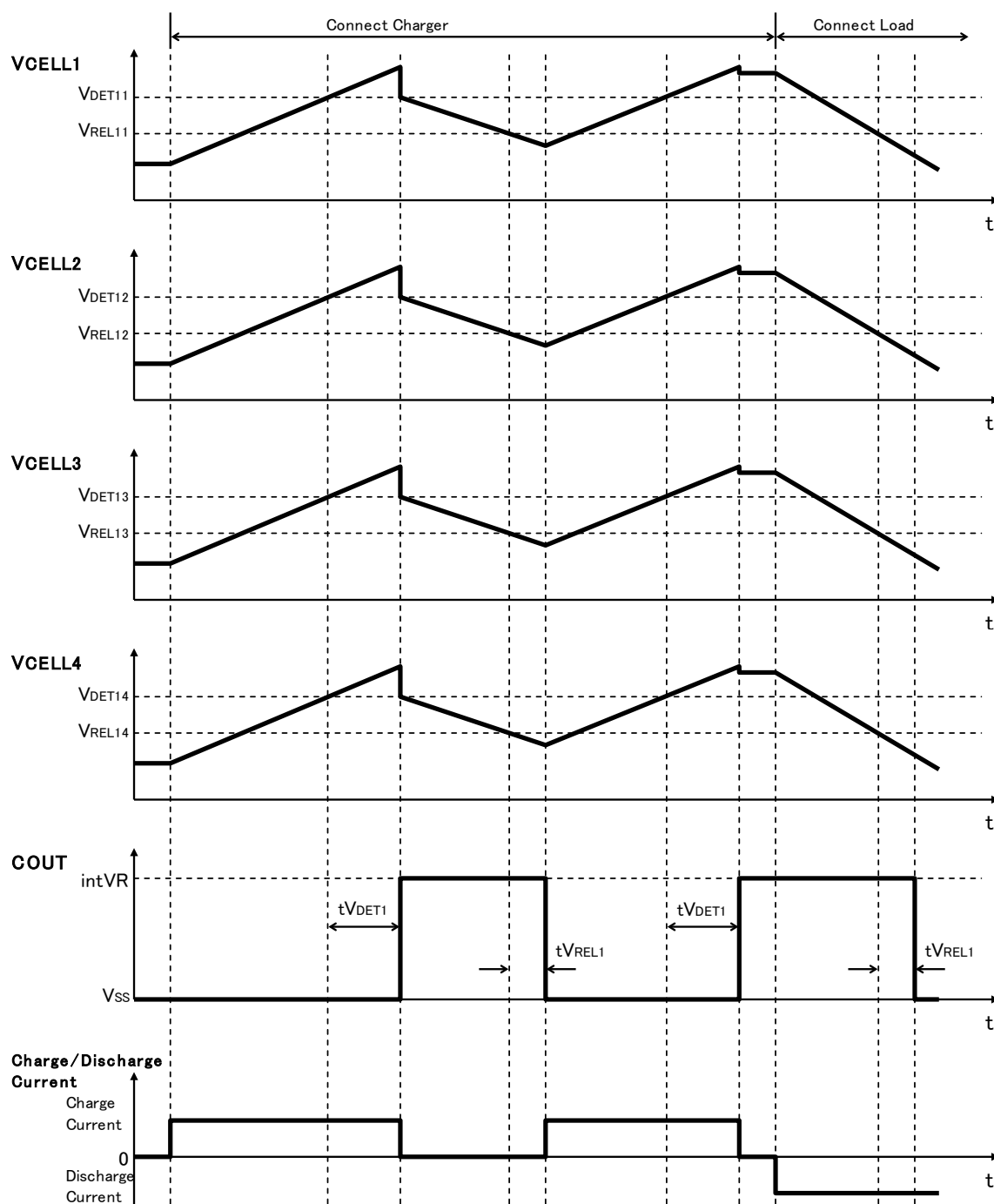
## THEORY OF OPERATION

### Overcharge Detection Circuit, VD1-n (n = 1, 2, 3, 4)

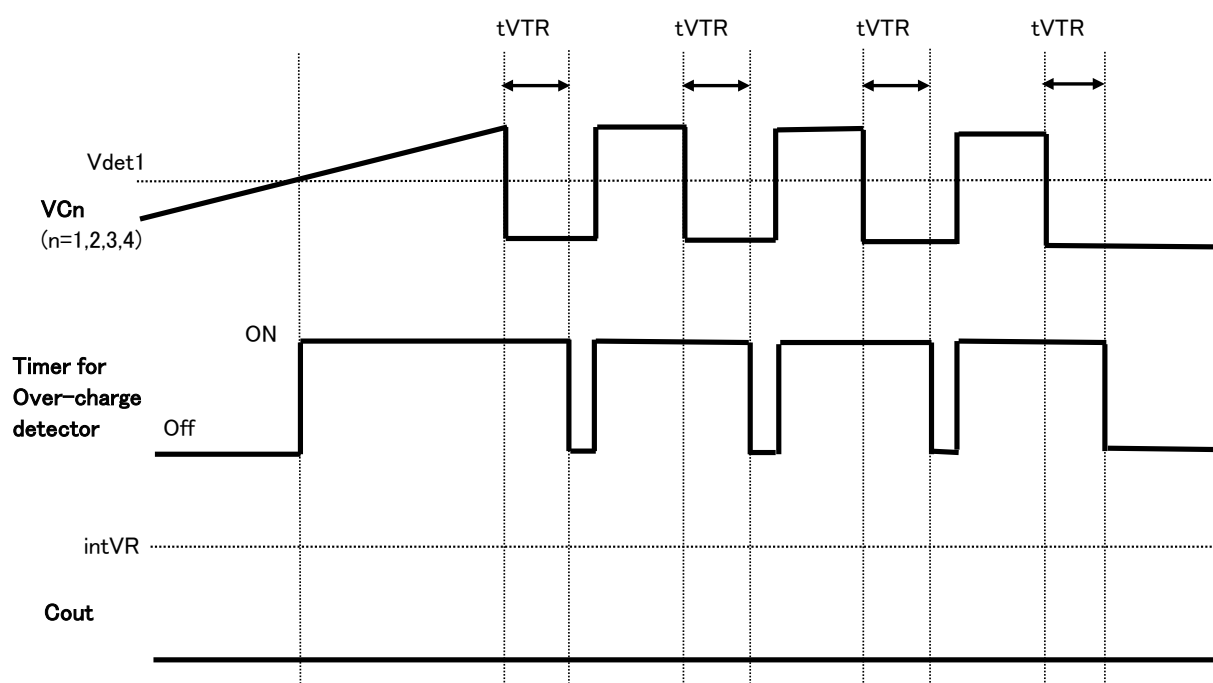
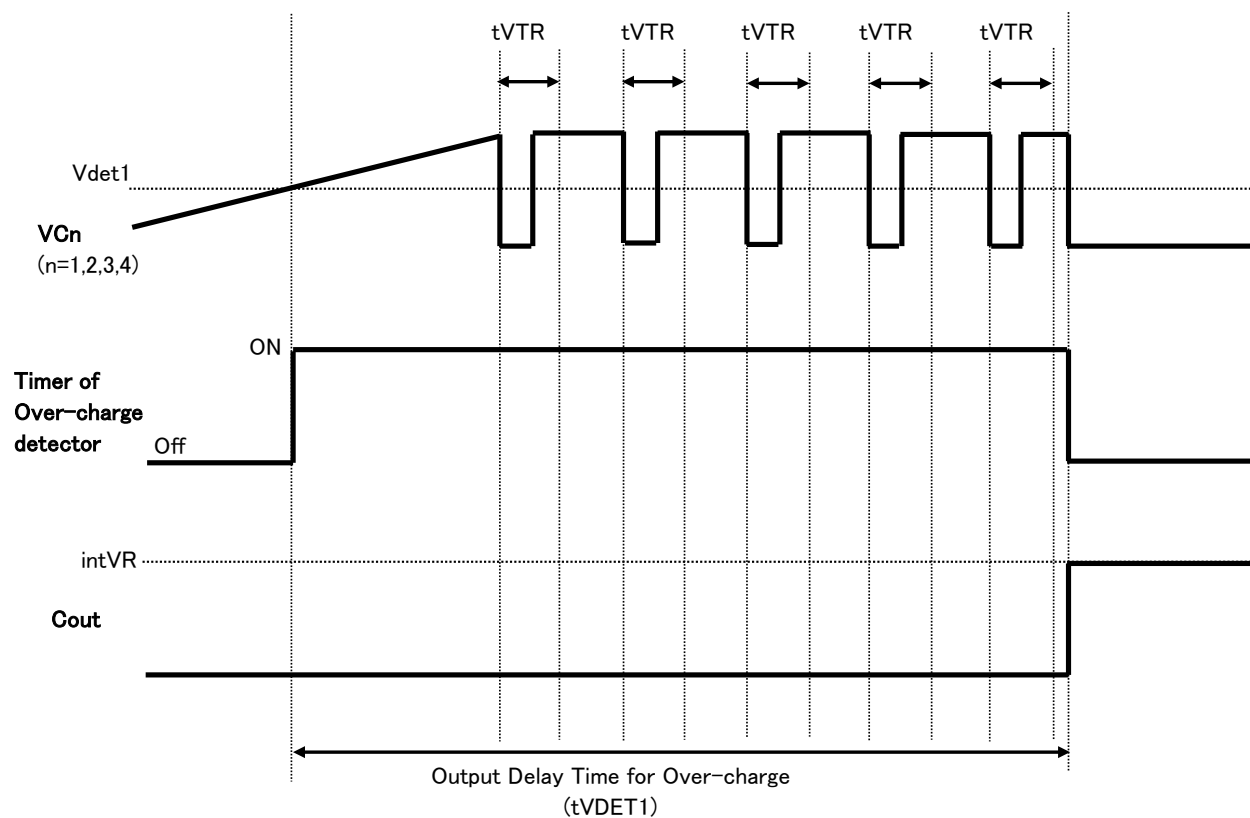
While the cells are charged, the voltage between VC1 pin and VC2 pin (Cell-1 voltage), the voltage between VC2 pin and VC3 pin (Cell-2 voltage), and the voltage between VC3 pin and VC4 pin (Cell-3 voltage), and the voltage between VC4 pin and VSS pin (Cell-4 voltage) are supervised. If at least one of the cells' voltage becomes equal or more than the over-charge detector threshold, the over-charge is detected, and an external charge control Nch. 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 over-charge 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 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. In the case of Timer Reset Delay available version, if all the cell voltages become lower than the over-charge detector threshold within the output delay time of over-charge detector by noise or other reasons, the time period is less than over-charge detector timer reset output delay time, the over-charge delay time is accumulated and maintained, and the accumulated delay time reaches the output delay time of over-charge, the over-charge 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 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.



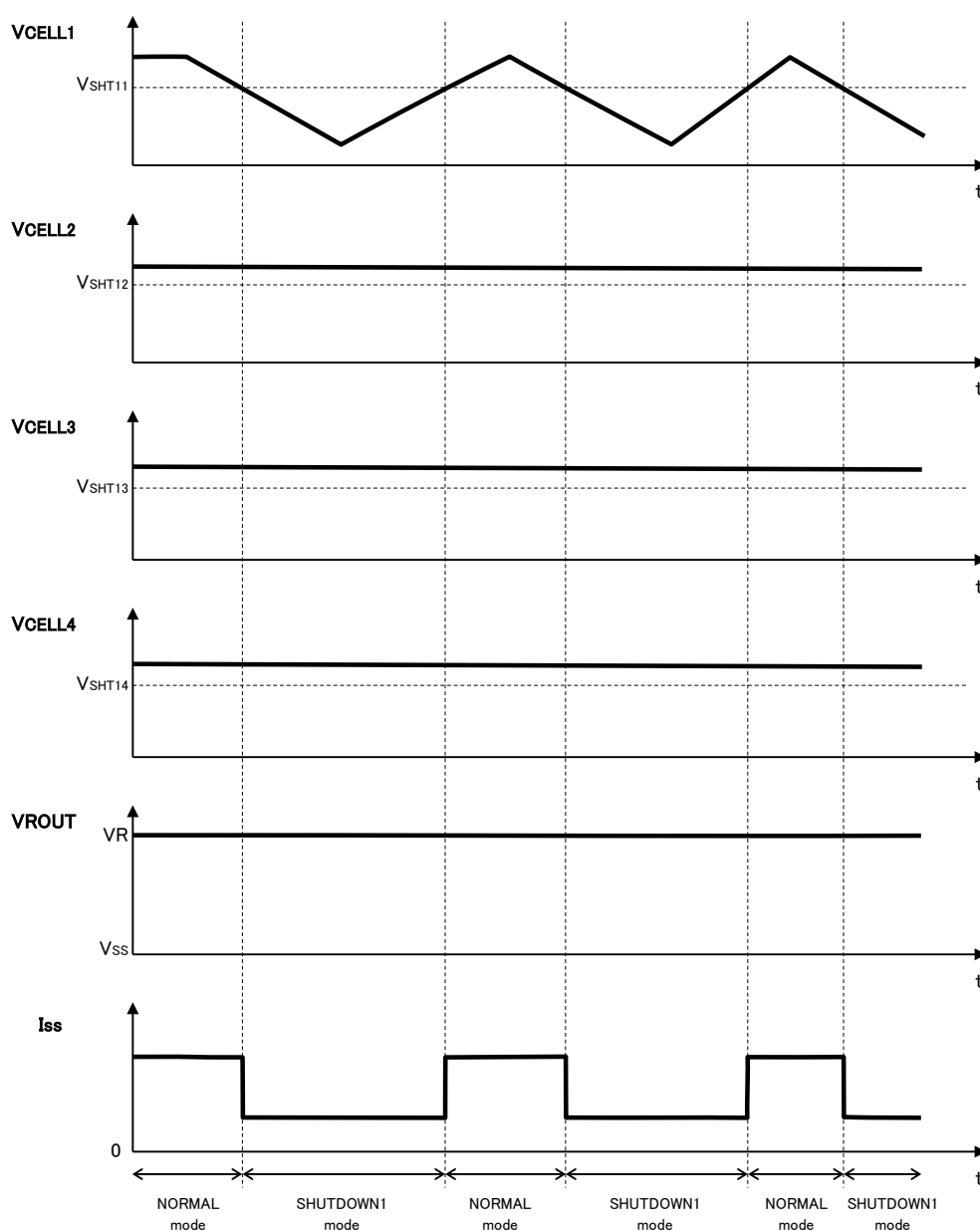
Overcharge Operation Timing Chart



Overcharge Operation Timing Chart (Timer Reset Delay Time Function included)

## Shutdown Function 1

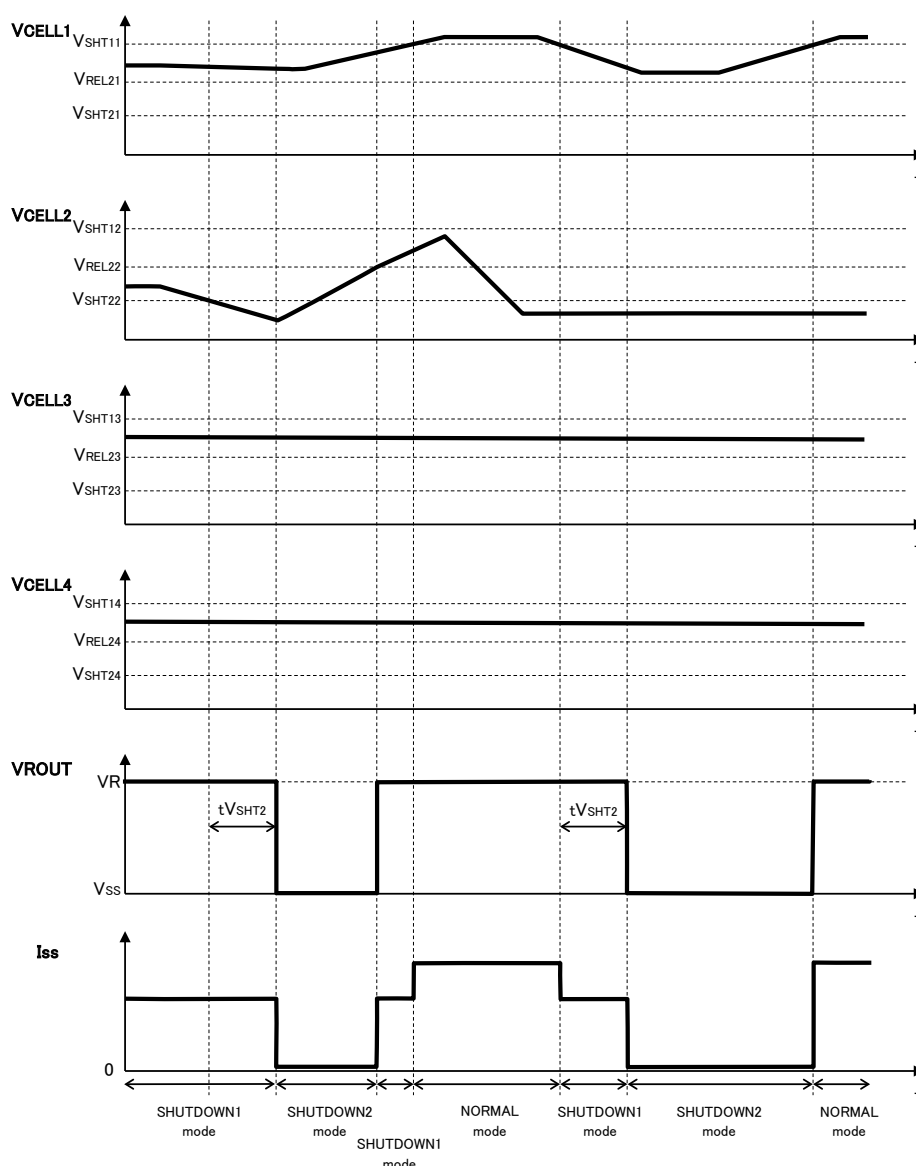
The voltage between VC1 pin and VC2 pin (Cell-1 voltage), the voltage between VC2 pin and VC3 pin (Cell-2 voltage), the voltage between VC3 pin and VC4 pin (Cell-3 voltage), and the voltage between VC4 pin and VSS pin (Cell-4 voltage) are supervised. If the cell voltage becomes equal or less than the shutdown detector threshold<sub>1</sub>, the over-charge detector of the cell is halted, as a result, the consumption current of IC itself (Shutdown<sub>1</sub> current) is extremely reduced. In shutdown mode<sub>1</sub>, the operation of regulator does not stop.



Shutdown Function 1 Operation Timing Chart

## Shutdown Function 2

The voltage between VC1 pin and VC2 pin (Cell-1 voltage), the voltage between VC2 pin and VC3 pin (Cell-2 voltage), the voltage between VC3 pin and VC4 pin (Cell-3 voltage), and the voltage between VC4 pin and VSS pin (Cell-4 voltage) are supervised. If the cell voltage becomes equal or less than the shutdown detector threshold2 and all the cells voltages are equal or less than the shutdown detector threshold1, all the circuits are halted and shut down, as a result, the consumption current of IC itself (Shutdown2 current) is extremely reduced. In shutdown mode2, the operation of regulator stops. When all the cells voltages become higher than the shutdown2 release voltage, VR output becomes H.



Shutdown Function 2 Operation Timing Chart

**Delay Shortening (DS) Function**

Applying a voltage of  $4\text{ V} \pm 0.2\text{ V}$  between VDD and VC1 can shorten the overcharge detection delay time ( $t_{VDET1}$ ) and the shutdown 2 detection delay time ( $t_{VSHT2}$ ) into approximately 1/80, likewise, the overcharge release delay time ( $t_{VREL1}$ ) into approximately 1/60.

**Voltage Regulator Function**

To drive the external RTC, the voltage regulator function is included in the R5439K.

**2-cell/ 3-cell Protection Alternative**

By short-circuiting between cells, the R5439K can meet as a protection IC for 2 or 3 cells placed in series.

The following table indicates pins to short-circuit to VC1 depending on protected cells.

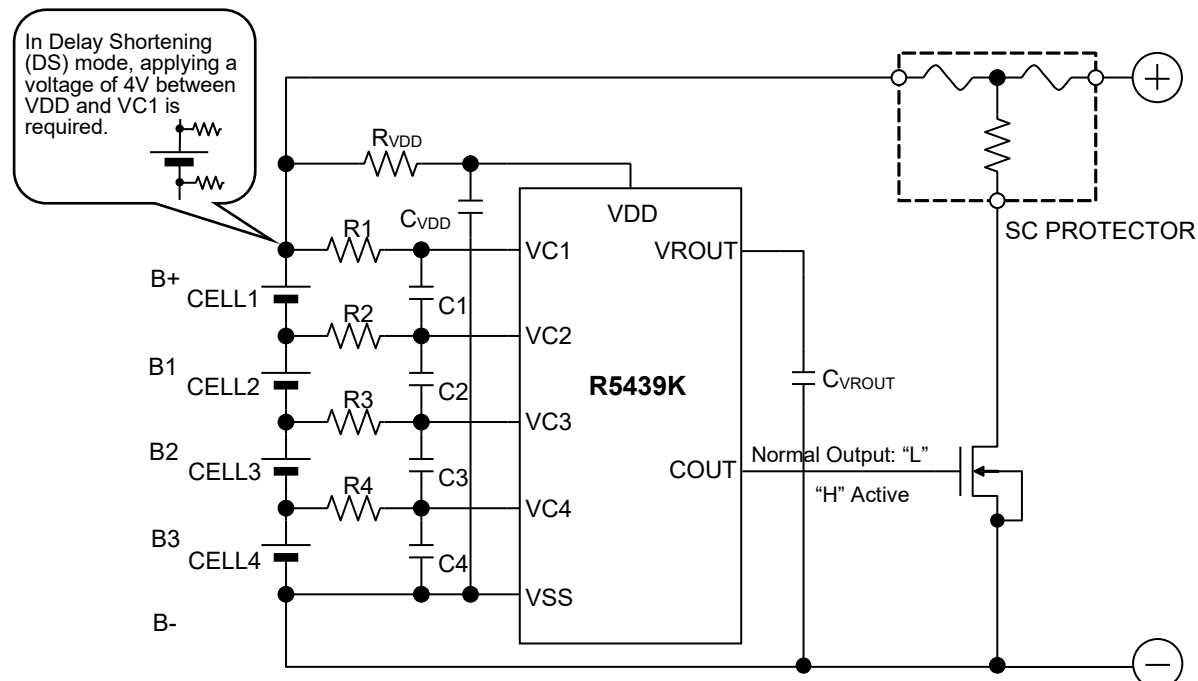
Protected Cells	Pins to short-circuit to VC1
2-cell protection	VC2 and VC3 pins
3-cell protection	VC2 pin

The 2- or 3-cell protection can only provide by the above connections.

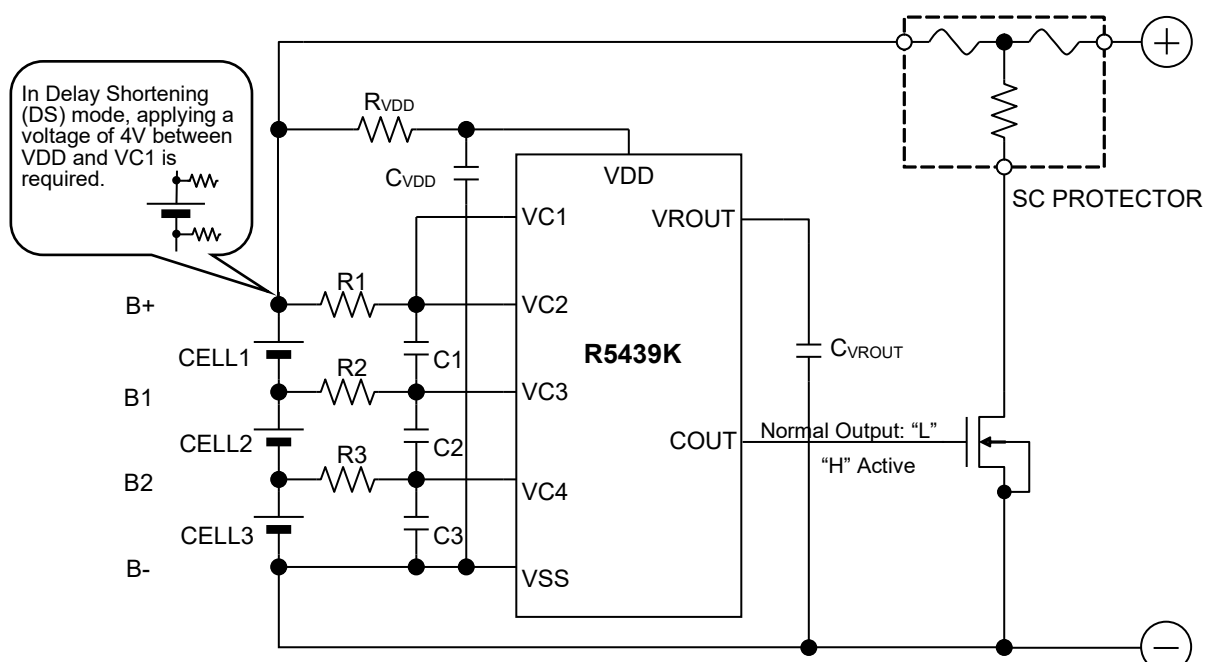


## APPLICATION INFORMATION

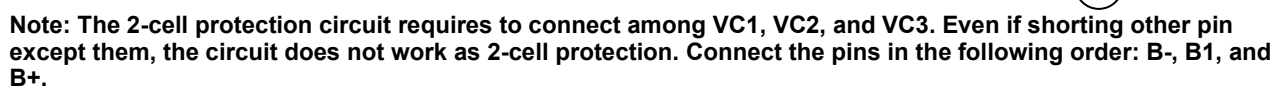
### Typical Application Circuits in Normal Mode (CMOS Output, Active-high)



4-cell Protection Circuit



3-cell Protection Circuit



## 2-cell Protection Circuit

Symbol	Typ.	Unit	Range
R <sub>VDD</sub>	100	Ω	100 to 1000
R1	1000	Ω	330 to 1000
R2	1000	Ω	330 to 1000
R3	1000	Ω	330 to 1000
R4	1000	Ω	330 to 1000
C <sub>VDD</sub>	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
C4	0.1	μF	0.01 to 1
C <sub>VROUT</sub>	0.1	μF	0.1

**Technical Notes on Selection Component**

- 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  $\Omega$  to 1 k $\Omega$ . The built-in voltage regulator (VR) is designed as a power source for an RTC. If the VR is used for other purpose,  $R_{VDD}$  value should be set so that  $V_{DD}$  does not become smaller than VC1-0.3V by  $R_{VDD}$  and a load current. If  $V_{DD}$  value is smaller than VC1-0.3V, the overvoltage detection voltage might shift or unexpected operation might result. To make a stable operation of the IC, the appropriate value range of  $C_{VDD}$  is from 0.01  $\mu$ F to 1.0  $\mu$ F.
- The voltage fluctuation is stabilized with R1 to R4 and C1 to C4. If a R1 to R4 is too large, by the conduction current at detection, the detector threshold may shift higher. Therefore, the appropriate value range of R1 to R4 is equal or less than 1 k $\Omega$ . To make a stable operation of the IC, the appropriate value range of C1 to C4 is 0.01  $\mu$ F 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.
- Our company cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in our products. If technical notes are not complied with the circuit which is used our products, we are not responsible for any damages and any accidents.
- 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.)

Gate-city Osaki East Tower 8F, 1-11-2 Osaki, Shinagawa, Tokyo, 141-0032

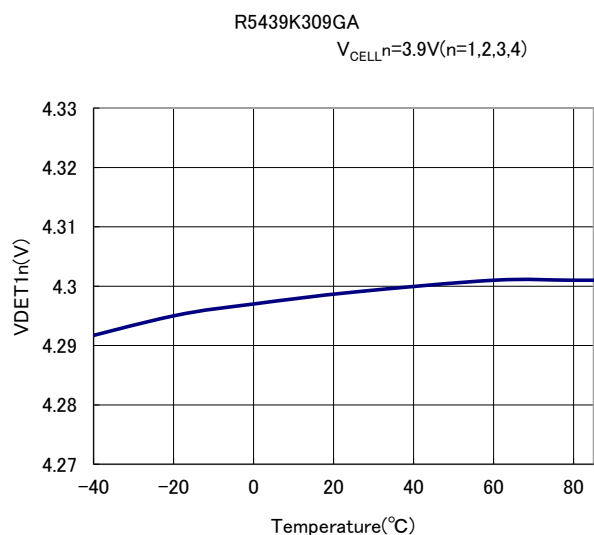
TEL: 03-5435-3946

URL: <http://www.dexerials.jp>

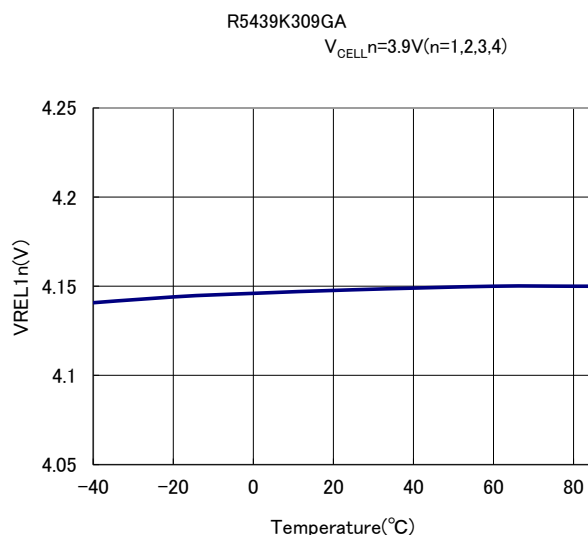
## TYPICAL CHARACTERISTICS (vs. Ambient Temperature)

Note: Typical Characteristics are intended to be used as reference data; they are not guaranteed.

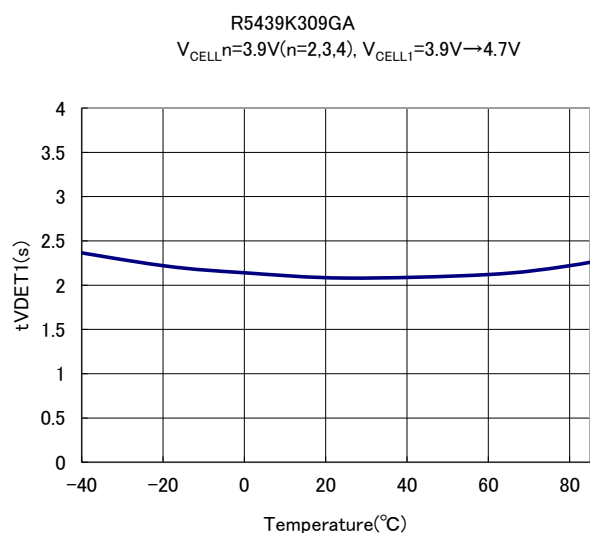
### 1) CELLn Overcharge Detector Threshold



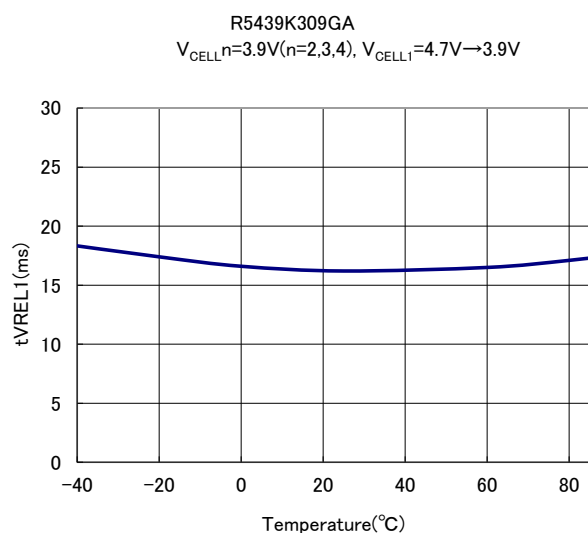
### 2) CELLn Overcharge Release Voltage



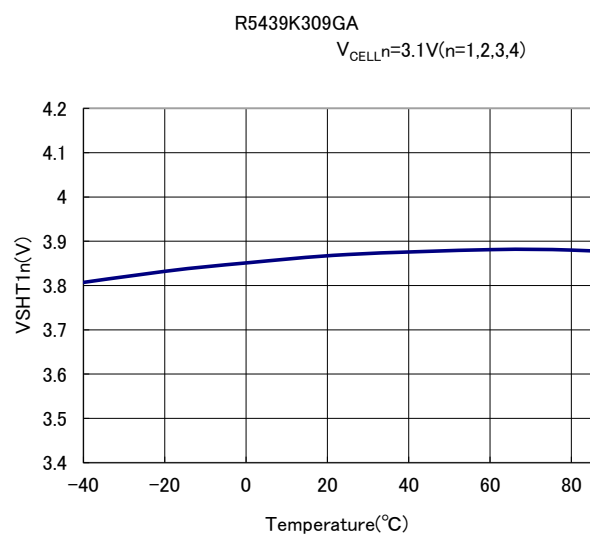
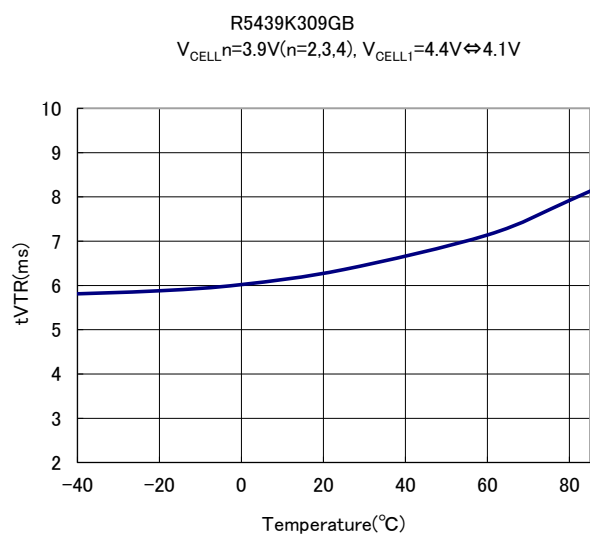
### 3) Overcharge Detection Output Delay Time



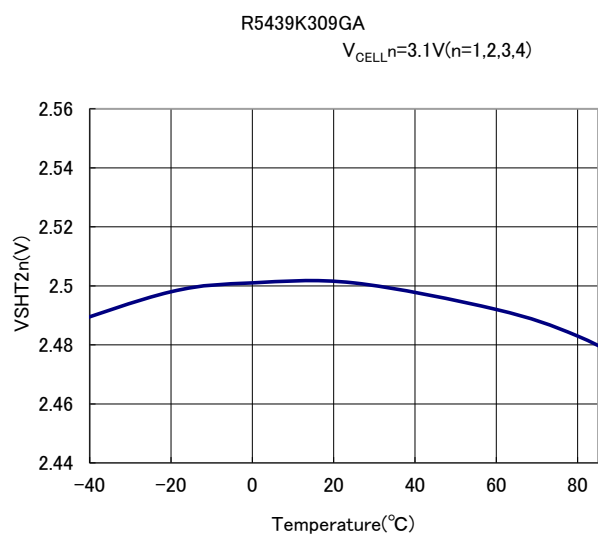
### 4) Overcharge Release Output Delay Time



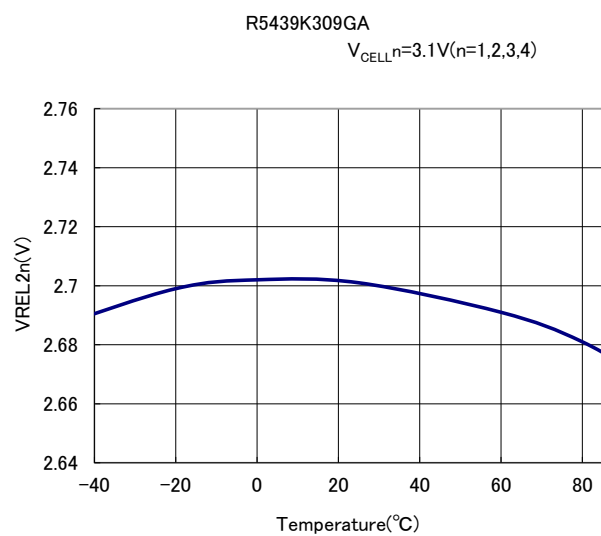
## 5) Output Delay Time of Overcharge Timer Reset    6) CELLn Shutdown 1 Detector Threshold



## 7) CELLn Shutdown 2 Detector Threshold

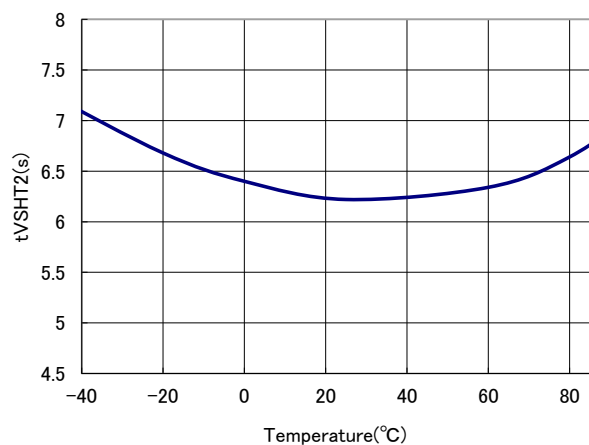


## 8) CELLn Shutdown 2 Release Voltage

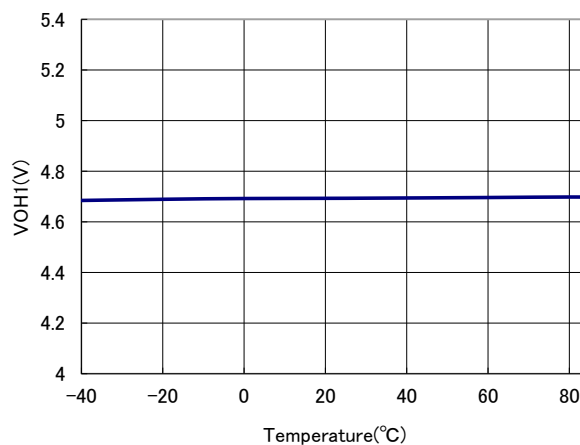


## 9) Shutdown 2 Output Delay Time

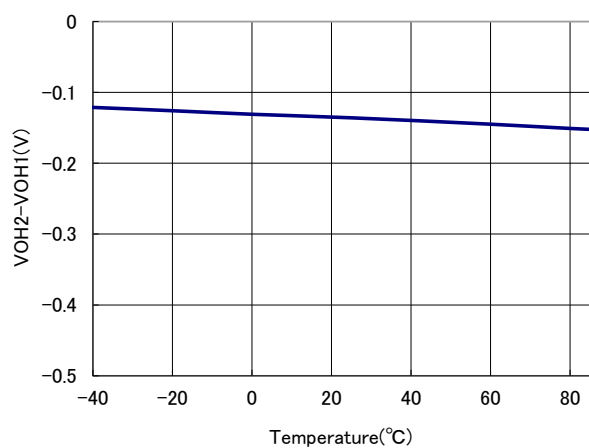
R5439K309GA  
 $V_{CELLn}=3.1V(n=2,3,4)$ ,  $V_{CELL1}=3.0V \rightarrow 2.0V$

10) C<sub>OUT</sub> Pch ON Voltage (No Load)

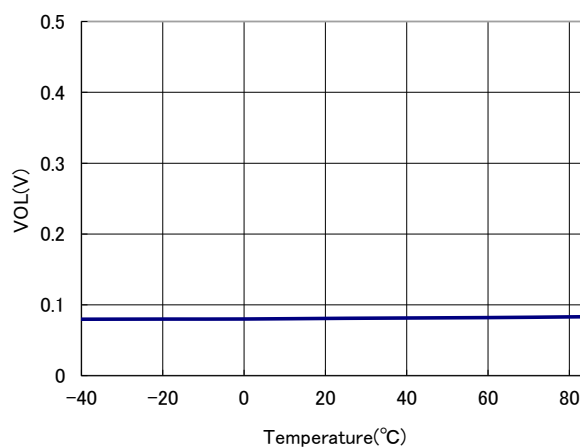
R5439K309GA  
 $V_{CELLn}=4.7V(n=1,2,3,4)$ ,  $I_{OH}=0\mu A$

11) C<sub>OUT</sub> Pch ON Voltage

R5439K309GA  
 $V_{CELLn}=4.7V(n=1,2,3,4)$ ,  $I_{OH}=-50\mu A$

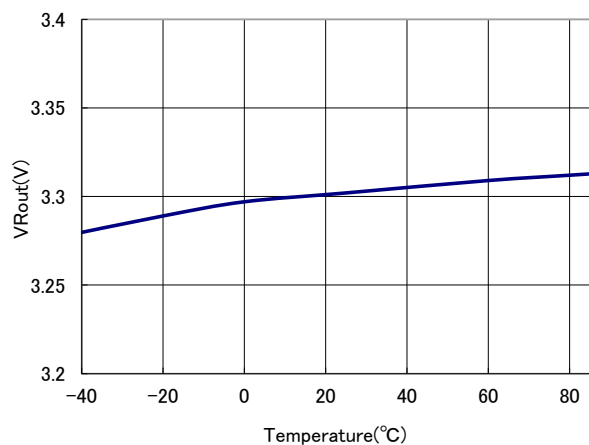
12) C<sub>OUT</sub> Nch ON Voltage

R5439K309GA  
 $V_{CELLn}=3.9V(n=1,2,3,4)$ ,  $I_{OH}=50\mu A$



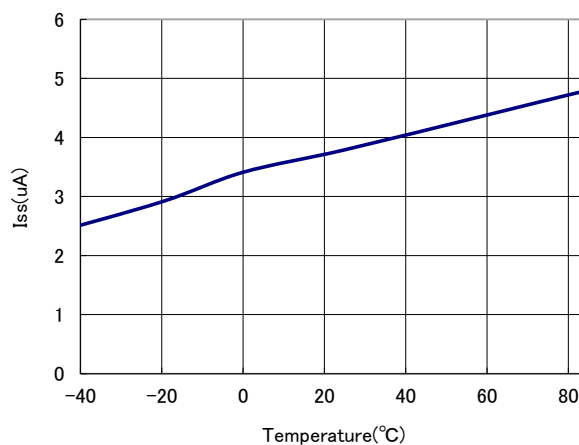
13)  $V_{\text{ROUT}}$  Output Voltage

R5439K309GA

 $V_{\text{CELL}}=3.9\text{V}(n=1,2,3,4)$ 

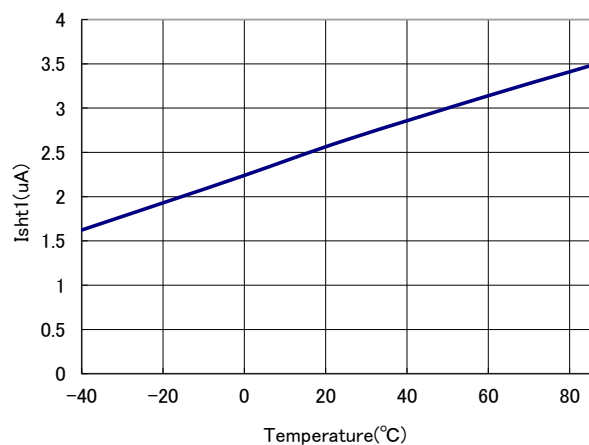
## 14) Supply Current

R5439K309GA

 $V_{\text{CELL}}=4.15\text{V}(n=1,2,3,4)$ 

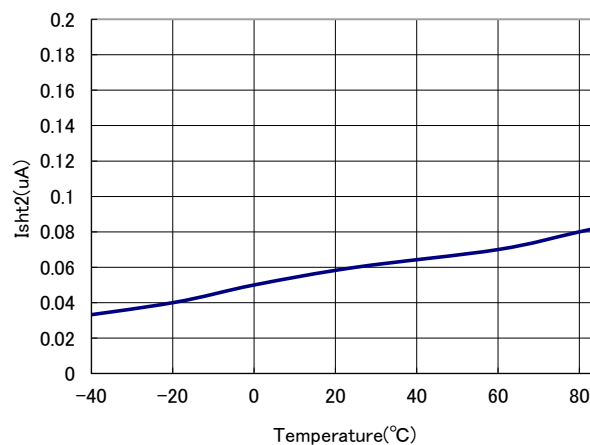
## 15) Shutdown 1 Current

R5439K309GA

 $V_{\text{CELL}}=3.1\text{V}(n=1,2,3,4)$ 

## 16) Shutdown 2 Current

R5439K309GA

 $V_{\text{CELL}}=2.0\text{V}(n=1,2,3,4)$ 

## 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).



The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51-7.

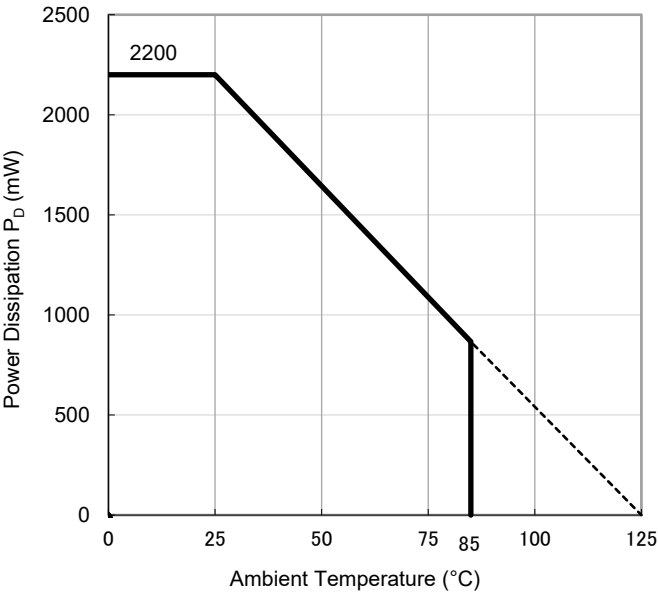
Measurement Conditions

Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square
Through-holes	φ 0.3 mm × 23 pcs

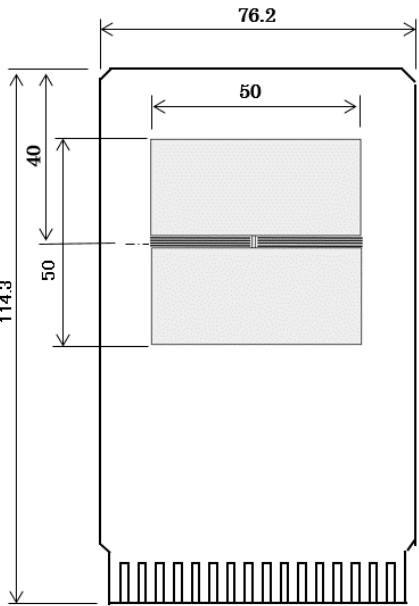
Measurement Result (Ta = 25°C, Tjmax = 125°C)

Item	Measurement Result
Power Dissipation	2200 mW
Thermal Resistance (θja)	θja = 45°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 14°C/W

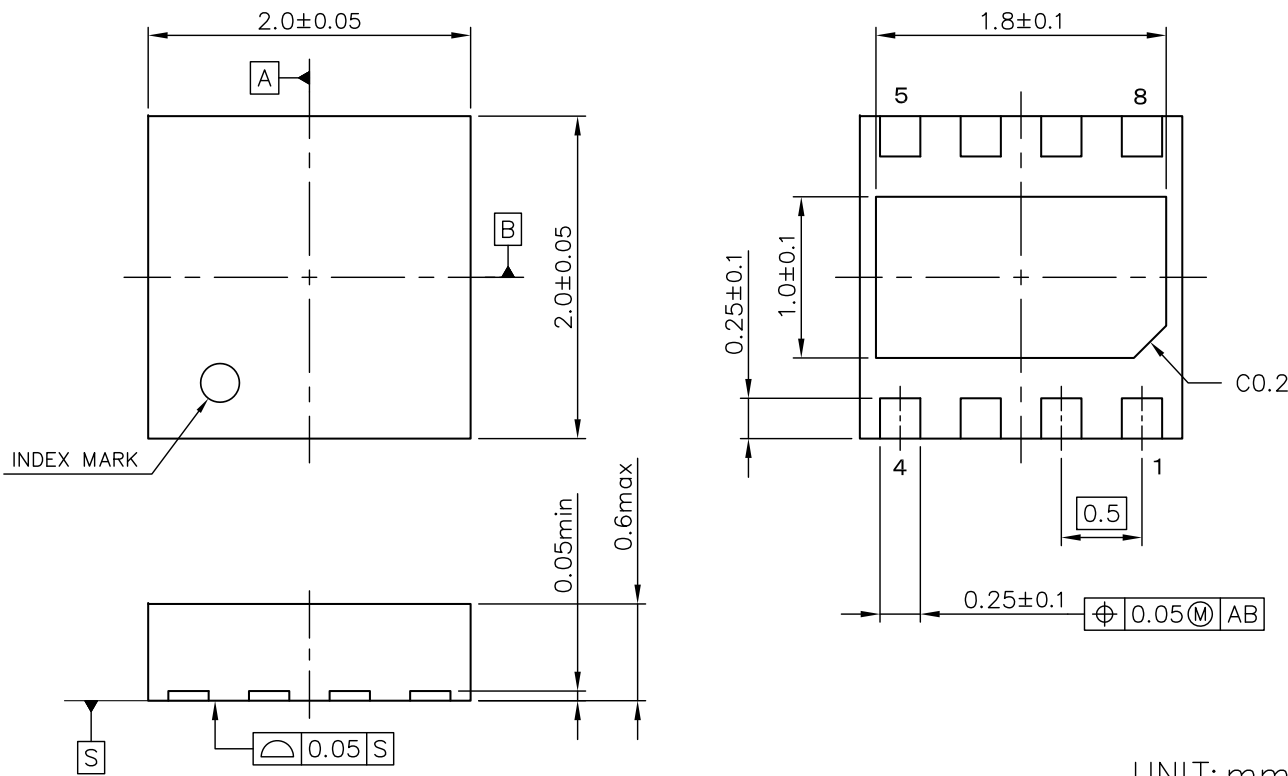
θja: Junction-to-Ambient Thermal Resistance  
ψjt: Junction-to-Top Thermal Characterization Parameter



Power Dissipation vs. Ambient Temperature



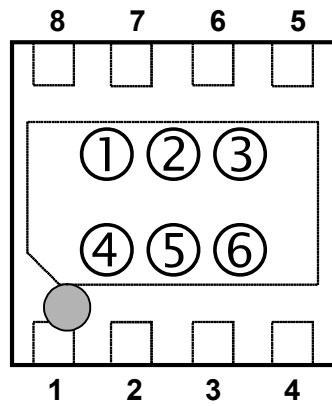
Measurement Board Pattern



DFN (PL) 2020-8 Package Dimensions

①②③④: Product Code … Refer to Part Marking List

⑤⑥: Lot Number … Alphanumeric Serial Number



DFN (PL) 2020-8 Part Markings

## R5439K Part Marking List

Product Name	① ② ③ ④	Product Name	① ② ③ ④
R5439K301GA	E T 0 0	R5439K314JA	E T 3 1
R5439K301HA	E T 0 1	R5439K319JA	E T 3 2
R5439K309GA	E T 0 2	R5439K317JA	E T 3 3
R5439K309HA	E T 0 3	R5439K329JA	E T 3 4
R5439K310GA	E T 0 4	R5439K328JA	E T 3 5
R5439K310HA	E T 0 5	R5439K330JA	E T 3 6
R5439K310JB	E T 0 6	R5439K331JA	E T 3 7
R5439K311GA	E T 0 7	R5439K332JA	E T 3 8
R5439K311HA	E T 0 8	R5439K323JA	E T 3 9
R5439K312GA	E T 0 9	R5439K327JA	E T 4 0
R5439K312HA	E T 1 0	R5439K333JA	E T 4 1
R5439K313JB	E T 1 1	R5439K334JA	E T 4 2
R5439K314JB	E T 1 2	R5439K335JA	E T 4 3
R5439K316JB	E T 1 3	R5439K324JA	E T 4 4
R5439K310KA	E T 1 4		
R5439K313KA	E T 1 5		
R5439K314KA	E T 1 6		
R5439K316KA	E T 1 7		
R5439K314HA	E T 1 8		
R5439K318KA	E T 1 9		
R5439K319JB	E T 2 0		
R5439K213HA	E T 2 1		
R5439K320KA	E T 2 2		
R5439K321KA	E T 2 3		
R5439K317JB	E T 2 4		
R5439K323JB	E T 2 5		
R5439K324JB	E T 2 6		
R5439K325JB	E T 2 7		
R5439K326JB	E T 2 8		
R5439K327JB	E T 2 9		
R5439K328JB	E T 3 0		

1. The products and the product specifications described in this document are subject to change or discontinuation of production without notice for reasons such as improvement. Therefore, before deciding to use the products, please refer to our sales representatives for the latest information thereon.
2. The materials in this document may not be copied or otherwise reproduced in whole or in part without the prior written consent of us.
3. This product and any technical information relating thereto are subject to complementary export controls (so-called KNOW controls) under the Foreign Exchange and Foreign Trade Law, and related politics ministerial ordinance of the law. (Note that the complementary export controls are inapplicable to any application-specific products, except rockets and pilotless aircraft, that are insusceptible to design or program changes.) Accordingly, when exporting or carrying abroad this product, follow the Foreign Exchange and Foreign Trade Control Law and its related regulations with respect to the complementary export controls.
4. The technical information described in this document shows typical characteristics and example application circuits for the products. The release of such information is not to be construed as a warranty of or a grant of license under our or any third party's intellectual property rights or any other rights.
5. The products listed in this document are intended and designed for use as general electronic components in standard applications (office equipment, telecommunication equipment, measuring instruments, consumer electronic products, amusement equipment etc.). Those customers intending to use a product in an application requiring extreme quality and reliability, for example, in a highly specific application where the failure or misoperation of the product could result in human injury or death should first contact us.
  - Aerospace Equipment
  - Equipment Used in the Deep Sea
  - Power Generator Control Equipment (nuclear, steam, hydraulic, etc.)
  - Life Maintenance Medical Equipment
  - Fire Alarms / Intruder Detectors
  - Vehicle Control Equipment (automotive, airplane, railroad, ship, etc.)
  - Various Safety Devices
  - Traffic control system
  - Combustion equipment

In case your company desires to use this product for any applications other than general electronic equipment mentioned above, make sure to contact our company in advance. Note that the important requirements mentioned in this section are not applicable to cases where operation requirements such as application conditions are confirmed by our company in writing after consultation with your company.

6. We are making our continuous effort to improve the quality and reliability of our products, but semiconductor products are likely to fail with certain probability. In order to prevent any injury to persons or damages to property resulting from such failure, customers should be careful enough to incorporate safety measures in their design, such as redundancy feature, fire containment feature and fail-safe feature. We do not assume any liability or responsibility for any loss or damage arising from misuse or inappropriate use of the products.
7. The products have been designed and tested to function within controlled environmental conditions. Do not use products under conditions that deviate from methods or applications specified in this datasheet. Failure to employ the products in the proper applications can lead to deterioration, destruction or failure of the products. We shall not be responsible for any bodily injury, fires or accident, property damage or any consequential damages resulting from misuse or misapplication of the products.
8. **Quality Warranty**
  - 8-1. **Quality Warranty Period**  
In the case of a product purchased through an authorized distributor or directly from us, the warranty period for this product shall be one (1) year after delivery to your company. For defective products that occurred during this period, we will take the quality warranty measures described in section 8-2. However, if there is an agreement on the warranty period in the basic transaction agreement, quality assurance agreement, delivery specifications, etc., it shall be followed.
  - 8-2. **Quality Warranty Remedies**  
When it has been proved defective due to manufacturing factors as a result of defect analysis by us, we will either deliver a substitute for the defective product or refund the purchase price of the defective product.  
Note that such delivery or refund is sole and exclusive remedies to your company for the defective product.
  - 8-3. **Remedies after Quality Warranty Period**  
With respect to any defect of this product found after the quality warranty period, the defect will be analyzed by us. On the basis of the defect analysis results, the scope and amounts of damage shall be determined by mutual agreement of both parties. Then we will deal with upper limit in Section 8-2. This provision is not intended to limit any legal rights of your company.
9. Anti-radiation design is not implemented in the products described in this document.
10. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
11. WLCSP products should be used in light shielded environments. The light exposure can influence functions and characteristics of the products under operation or storage.
12. Warning for handling Gallium and Arsenic (GaAs) products (Applying to GaAs MMIC, Photo Reflector). These products use Gallium (Ga) and Arsenic (As) which are specified as poisonous chemicals by law. For the prevention of a hazard, do not burn, destroy, or process chemically to make them as gas or power. When the product is disposed of, please follow the related regulation and do not mix this with general industrial waste or household waste.
13. Please contact our sales representatives should you have any questions or comments concerning the products or the technical information.



**Nisshinbo Micro Devices Inc.**

**Official website**

<https://www.nisshinbo-microdevices.co.jp/en/>

**Purchase information**

<https://www.nisshinbo-microdevices.co.jp/en/buy/>