

### R5463Kxxxxx SERIES

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EA-262-120711

## OUTLINE

The R5463Kxxxxx Series are high voltage CMOS-based protection ICs for over-charge/discharge of two-cell Lithium-ion (Li+) / Lithium polymer, further include a short circuit protection circuit for preventing large external short circuit current and the protection circuits against the excess discharge-current and excess charge current.

Each of these ICs is composed of six voltage detectors, a reference unit, a delay circuit, a short circuit protector, an oscillator, a counter, and a logic circuit. When the over-charge voltage threshold or excess-charge current threshold crosses the each detector threshold from a low value to a high value, the output of C<sub>OUT</sub> pin switches to "L" level after internal fixed delay time. To release over-charge detector after detecting over-charge, the detector can be reset and the output of C<sub>OUT</sub> becomes "H" when a kind of load is connected to V<sub>DD</sub> after a charger is disconnected from the battery pack and the cell voltage becomes lower than over-charge detector threshold. In case that a charger is continuously connected to the battery pack, if the cell voltage becomes lower than the over-charge released voltage, over-charge state is also released.

The output of D<sub>OUT</sub> pin, the output of the over-discharge detector and the excess discharge-current detector, switches to "L" level after internally fixed delay time, when discharged voltage crosses the detector threshold from a high value to a value lower than V<sub>DET2</sub>. To release over-discharge detector, after detecting over-discharge voltage, connect a charger to the battery pack, and when the battery supply voltage becomes higher than the over-discharge detector threshold, the over-discharge detector is released and the voltage of D<sub>OUT</sub> pin becomes "H".

If the battery is discharged lower than maximum voltage for inhibition of charger, recharge current is not acceptable.

After detecting excess-discharge current or short current, when the load is disconnected, the excess discharged or short condition is released and D<sub>OUT</sub> becomes "H".

After detecting over-discharge voltage, supply current will be kept extremely low by halting internal circuits' operation.

When the output of C<sub>OUT</sub> is "H", if V- pin level is set at -1.6V, the delay time of over-charge and over-discharge detector can be shortened. Especially, the delay time of the over-charge detector can be reduced into approximately 1/60 and test time for protection circuit PCB can be reduced. The output type of C<sub>OUT</sub> and D<sub>OUT</sub> is CMOS.

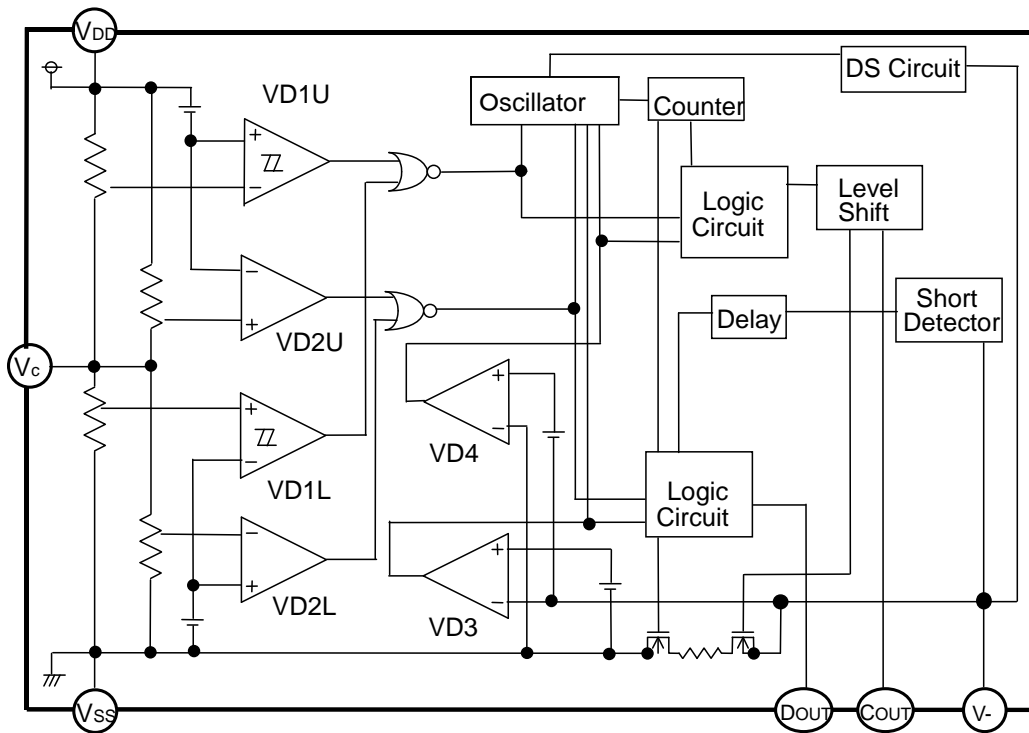
## FEATURES

- Manufactured with High Voltage Tolerant Process... Absolute Maximum Rating 30V
- Low supply current..... Supply current (At normal mode) Typ. 4.0μA  
Standby current Max. 0.1μA
- High accuracy detector threshold..... Over-charge detector (Ta=25°C) ±20mV  
(Ta=-5°C to 55°C) ±25mV  
Over-discharge detector ±1.0%  
Excess discharge-current detector (G ver.) ±10mV  
(J ver.) ±10%  
Excess charge-current detector ±20mV
- Variety of detector threshold ..... Over-charge detector threshold 3.65V-4.32V step of 0.005V  
Over-discharge detector threshold 2.0V-3.2V step of 0.005V  
Excess discharge-current threshold (G ver.) 0.05V-0.20V step of 0.005V  
(J ver.) 0.20V-0.40V step of 0.005V  
Excess charge-current threshold -0.2V--0.1V step of 0.005V
- Internal fixed Output delay time ..... Over-charge detector Output Delay 1s  
Over-discharge detector Output Delay 128ms  
Excess discharge-current detector Output Delay 12ms  
Excess charge-current detector Output Delay 8ms  
Short Circuit detector Output Delay 300μs
- Output Delay Time Shortening Function ..... At COUT is "H", if V- level is set at -1.6V, the Output Delay time of detect the over-charge and over-discharge can be reduced.  
(Delay Time for over-charge becomes about 1/60 of normal state.)
- 0V-battery charge..... Unacceptable
- Ultra Small package ..... DFN(PLP)1820-6B

## APPLICATIONS

- Li+ / Li Polymer protector of over-charge, over-discharge, excess-current for battery pack
- High precision protectors for cell-phones and any other gadgets using on board Li+ / Li Polymer battery

## BLOCK DIAGRAMS



## SELECTION GUIDE

In the R5463Kxxxxx Series, input threshold of over-charge, over-discharge, excess discharge current, and the package and taping can be designated.

Part Number is designated as follows:

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R5463K2xx\$*-TR	DFN(PLP)1820-6B	5,000pcs	Yes	Yes

xx :Serial Number for the R5463K Series designating voltages such as over-charge threshold, over-charge, over-discharge threshold, over-discharge current, over-charge current, short voltage.

\$ : Designation of Output delay time option.

	Over-charge Delay time (s)	Over-discharge Delay time (ms)	Over-discharge Current Delay time (ms)	Over-charge Current Delay time (ms)	Short Delay time (μs)
R5463KxxxA*	1.0	128	12	8	300

\* : Designation of protection type.

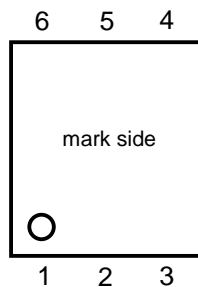
	Over-charge Released condition	Over-discharge Released condition	0V battery Charge	Adustable Range of Excess Charge-current Threshold
R5463Kxxx\$G	Auto Release	Latch	NG	0.05 to 0.20V
R5463Kxxx\$J	Auto Release	Latch	NG	0.20 to 0.40V

## PRODUCT NAME LIST

Code	VDET1 (V)	VREL1 (V)	VDET2 (V)	VREL2 (V)	VDET3 (V)	VDET4 (V)
R5463K217AG	4.280	4.080	2.000	-	0.200	-0.100
R5463K221AJ	4.300	4.100	2.600	-	0.370	-0.160
R5463K224AG	4.280	4.080	2.000	-	0.110	-0.100

## PIN CONFIGURATIONS

DFN(PLP)1820-6B



## PIN DESCRIPTION

Pin No.	Symbol	Pin Description
1	C <sub>OUT</sub>	Output pin of over-charge detection, CMOS output
2	V-	Pin for charger negative input
3	D <sub>OUT</sub>	Output pin of over-discharge detection, CMOS output
4	V <sub>SS</sub>	Vss pin. Ground pin for the IC
5	V <sub>DD</sub>	Power supply pin, the substrate voltage level of the IC.
6	VC	Input Pin of the center voltage between two-cell

The backside tab of DFN(PLP)1820-6B package is connected to the substrate level. (V<sub>DD</sub>) Note that avoiding short with other level.

## ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Ratings	Unit
V <sub>DD</sub>	Supply voltage	-0.3 to 12	V
V <sub>C</sub>	Input Voltage Center pin voltage between two-cell	V <sub>SS</sub> -0.3 to V <sub>DD</sub> +0.3	V
V-	Charger negative input V- pin	V <sub>DD</sub> -30 to V <sub>DD</sub> +0.3	V
V <sub>C<sub>OUT</sub></sub>	Output voltage C <sub>OUT</sub> pin	V <sub>DD</sub> -30 to V <sub>DD</sub> +0.3	V
V <sub>D<sub>OUT</sub></sub>	D <sub>OUT</sub> pin	V <sub>SS</sub> -0.3 to V <sub>DD</sub> +0.3	V
P <sub>D</sub>	Power dissipation	150	mW
T <sub>a</sub>	Operating temperature range	-40 to 85	°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 life time 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 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.

## ELECTRICAL CHARACTERISTICS

## R5463KxxxAG

Unless otherwise specified Ta=25°C

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Operating Input Voltage	V <sub>DD1</sub>	V <sub>DD</sub> -V <sub>SS</sub>	1.5		10	V
Maximum Operating Voltage for Inhibition of Charger	V <sub>nochg</sub>	V <sub>DD</sub> -V <sub>C</sub> or V <sub>C</sub> -V <sub>SS</sub>	0.6	0.8	1.0	V
Cell1 Over-charge Detector Threshold	V <sub>DET1U</sub>	R1=330Ω R1=330Ω, (Ta=-5°C to 55°C)*Note1	V <sub>DET1U</sub> -0.020 V <sub>DET1U</sub> -0.025	V <sub>DET1U</sub>	V <sub>DET1U</sub> +0.020 V <sub>DET1U</sub> +0.025	V
Cell1 Over-charge Released Voltage	V <sub>REL1U</sub>	R1=330Ω	V <sub>REL1U</sub> -0.050	V <sub>REL1U</sub>	V <sub>REL1U</sub> +0.050	V
Cell2 Over-charge Detector threshold	V <sub>DET1L</sub>	R2=330Ω R2=330Ω, (Ta=-5°C to 55°C)*Note1	V <sub>DET1L</sub> -0.020 V <sub>DET1L</sub> -0.025	V <sub>DET1L</sub>	V <sub>DET1L</sub> +0.020 V <sub>DET1L</sub> +0.025	V
Cell2 Over-charge Released Voltage	V <sub>REL1L</sub>	R2=330Ω	V <sub>REL1L</sub> -0.050	V <sub>REL1L</sub>	V <sub>REL1L</sub> +0.050	V
Output Delay of Over-charge	tV <sub>DET1</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.5V to 4.5V V <sub>C</sub> -V <sub>SS</sub> =3.5V	0.7	1.0	1.3	s
Output Delay of Release from Over-charge	tV <sub>REL1</sub>	V <sub>DD</sub> -V <sub>C</sub> =4.5V to 3.5V, V <sub>C</sub> -V <sub>SS</sub> =3.5V	11	16	21	ms
Cell1 Over-discharge Threshold	V <sub>DET2U</sub>	Detect falling edge of the input voltage	V <sub>DET2U</sub> × 0.990	V <sub>DET2U</sub>	V <sub>DET2U</sub> × 1.010	V
Cell2 Over-discharge Threshold	V <sub>DET2L</sub>	Detect falling edge of the input voltage	V <sub>DET2L</sub> × 0.990	V <sub>DET2L</sub>	V <sub>DET2L</sub> × 1.010	V
Output Delay of Over-discharge	tV <sub>DET2</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.5V to 1.5V V <sub>C</sub> -V <sub>SS</sub> =3.5V	89	128	167	ms
Output Delay of Release from Over-discharge	tV <sub>REL2</sub>	V <sub>DD</sub> -V <sub>C</sub> =1.5V to 3.5V V <sub>C</sub> -V <sub>SS</sub> =3.5V	0.7	1.2	1.7	ms
Excess Discharge-current Threshold	V <sub>DET3</sub>	Detect rising edge of 'V-' pin voltage	V <sub>DET3</sub> -0.010	V <sub>DET3</sub>	V <sub>DET3</sub> +0.010	V
Output Delay of Excess Discharge-current	tV <sub>DET3</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.5V, V <sub>C</sub> -V <sub>SS</sub> =3.5V V <sub>-</sub> =0V to 0.5V	8	12	16	ms
Output Delay of Release from Excess Discharge-current	tV <sub>REL3</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.5V, V <sub>C</sub> -V <sub>SS</sub> =3.5V V <sub>-</sub> =3V to 0V	0.7	1.2	1.7	ms
Short Protection Voltage	V <sub>SHORT</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.5V, V <sub>C</sub> -V <sub>SS</sub> =3.5V	0.6	1.0	1.4	V
Delay Time for Short Protection	t <sub>SHORT</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.5V, V <sub>C</sub> -V <sub>SS</sub> =3.5V V <sub>-</sub> =0V to 1.5V	150	300	500	μs
Reset Resistance for Excess Current Protection	R <sub>SHORT</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.6V, V <sub>C</sub> -V <sub>SS</sub> =3.6V V <sub>-</sub> =1V	25	40	75	kΩ
Excess Charge-current Threshold	V <sub>DET4</sub>	Detect falling edge of 'V-' pin voltage	V <sub>DET4</sub> -0.020	V <sub>DET4</sub>	V <sub>DET4</sub> +0.020	V
Output Delay of Excess Charge-current	tV <sub>DET4</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.5V, V <sub>C</sub> -V <sub>SS</sub> =3.5V V <sub>-</sub> =0V to -1V	5	8	11	ms
Output Delay of Release from Excess Charge-current	tV <sub>REL4</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.5V, V <sub>C</sub> -V <sub>SS</sub> =3.5V V <sub>-</sub> =-1V to 0V	0.7	1.2	1.7	ms
Delay Shortening Mode Voltage	V <sub>DS</sub>	V <sub>DD</sub> -V <sub>C</sub> =4.4V, V <sub>C</sub> -V <sub>SS</sub> =4.4V	-2.2	-1.6	-1.0	V
Nch ON-Voltage of C <sub>OUT</sub>	V <sub>OL1</sub>	I <sub>ol</sub> =50μA, V <sub>DD</sub> -V <sub>C</sub> =4.5V V <sub>C</sub> -V <sub>SS</sub> =4.5V		0.4	0.5	V
Pch ON-Voltage of C <sub>OUT</sub>	V <sub>OH1</sub>	I <sub>oh</sub> =-50μA, V <sub>DD</sub> -V <sub>C</sub> =3.9V V <sub>C</sub> -V <sub>SS</sub> =3.9V	6.8	7.4		V
Nch ON-Voltage of D <sub>OUT</sub>	V <sub>OL2</sub>	I <sub>ol</sub> =50μA, V <sub>DD</sub> -V <sub>C</sub> =1.9V V <sub>C</sub> -V <sub>SS</sub> =1.9V		0.2	0.5	V
Pch ON-Voltage of D <sub>OUT</sub>	V <sub>OH2</sub>	I <sub>oh</sub> =-50μA, V <sub>DD</sub> -V <sub>C</sub> =3.9V V <sub>C</sub> -V <sub>SS</sub> =3.9V	6.8	7.4		V
Supply Current	I <sub>DD</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.9V, V <sub>C</sub> -V <sub>SS</sub> =3.9V V <sub>-</sub> =0V		4.0	8.0	μA
Standby Current	I <sub>STB</sub>	V <sub>DD</sub> -V <sub>C</sub> =1.9V, V <sub>C</sub> -V <sub>SS</sub> =1.9V			0.1	μA

\*Note1: Considering of variation in process parameters, we compensate for this characteristic related to temperature by laser-trim, however, this specification is guaranteed by design, not tested.

## R5463KxxxAJ

Unless otherwise specified Ta=25°C

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Operating Input Voltage	V <sub>DD1</sub>	V <sub>DD</sub> -V <sub>SS</sub>	1.5		10	V
Maximum Operating Voltage for Inhibition of Charger	V <sub>nochg</sub>	V <sub>DD</sub> -V <sub>C</sub> or V <sub>C</sub> -V <sub>SS</sub>	0.6	0.8	1.0	V
Cell1 Over-charge Detector Threshold	V <sub>DET1U</sub>	R1=330Ω R1=330Ω, (Ta=-5°C to 55°C)*Note1	V <sub>DET1U</sub> -0.020 V <sub>DET1U</sub> -0.025	V <sub>DET1U</sub>	V <sub>DET1U</sub> +0.020 V <sub>DET1U</sub> +0.025	V
Cell1 Over-charge Released Voltage	V <sub>REL1U</sub>	R1=330Ω	V <sub>REL1U</sub> -0.050	V <sub>REL1U</sub>	V <sub>REL1U</sub> +0.050	V
Cell2 Over-charge Detector threshold	V <sub>DET1L</sub>	R2=330Ω R2=330Ω, (Ta=-5°C to 55°C)*Note1	V <sub>DET1L</sub> -0.020 V <sub>DET1L</sub> -0.025	V <sub>DET1L</sub>	V <sub>DET1L</sub> +0.020 V <sub>DET1L</sub> +0.025	V
Cell2 Over-charge Released Voltage	V <sub>REL1L</sub>	R2=330Ω	V <sub>REL1L</sub> -0.050	V <sub>REL1L</sub>	V <sub>REL1L</sub> +0.050	V
Output Delay of Over-charge	tV <sub>DET1</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.5V to 4.5V V <sub>C</sub> -V <sub>SS</sub> =3.5V	0.7	1.0	1.3	s
Output Delay of Release from Over-charge	tV <sub>REL1</sub>	V <sub>DD</sub> -V <sub>C</sub> =4.5V to 3.5V, V <sub>C</sub> -V <sub>SS</sub> =3.5V	11	16	21	ms
Cell1 Over-discharge Threshold	V <sub>DET2U</sub>	Detect falling edge of the input voltage	V <sub>DET2U</sub> × 0.990	V <sub>DET2U</sub>	V <sub>DET2U</sub> × 1.010	V
Cell2 Over-discharge Threshold	V <sub>DET2L</sub>	Detect falling edge of the input voltage	V <sub>DET2L</sub> × 0.990	V <sub>DET2L</sub>	V <sub>DET2L</sub> × 1.010	V
Output Delay of Over-discharge	tV <sub>DET2</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.5V to 1.5V V <sub>C</sub> -V <sub>SS</sub> =3.5V	89	128	167	ms
Output Delay of Release from Over-discharge	tV <sub>REL2</sub>	V <sub>DD</sub> -V <sub>C</sub> =1.5V to 3.5V V <sub>C</sub> -V <sub>SS</sub> =3.5V	0.7	1.2	1.7	ms
Excess Discharge-current Threshold	V <sub>DET3</sub>	Detect rising edge of 'V-' pin voltage	V <sub>DET3</sub> × 0.900	V <sub>DET3</sub>	V <sub>DET3</sub> × 1.100	V
Output Delay of Excess Discharge-current	tV <sub>DET3</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.5V, V <sub>C</sub> -V <sub>SS</sub> =3.5V V <sub>-</sub> =0V to 0.5V	8	12	16	ms
Output Delay of Release from Excess Discharge-current	tV <sub>REL3</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.5V, V <sub>C</sub> -V <sub>SS</sub> =3.5V V <sub>-</sub> =3V to 0V	0.7	1.2	1.7	ms
Short Protection Voltage	V <sub>SHORT</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.5V, V <sub>C</sub> -V <sub>SS</sub> =3.5V	0.6	1.0	1.4	V
Delay Time for Short Protection	t <sub>SHORT</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.5V, V <sub>C</sub> -V <sub>SS</sub> =3.5V V <sub>-</sub> =0V to 1.5V	150	300	500	μs
Reset Resistance for Excess Current Protection	R <sub>SHORT</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.6V, V <sub>C</sub> -V <sub>SS</sub> =3.6V V <sub>-</sub> =1V	25	40	75	kΩ
Excess Charge-current Threshold	V <sub>DET4</sub>	Detect falling edge of 'V-' pin voltage	V <sub>DET4</sub> -0.020	V <sub>DET4</sub>	V <sub>DET4</sub> +0.020	V
Output Delay of Excess Charge-current	tV <sub>DET4</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.5V, V <sub>C</sub> -V <sub>SS</sub> =3.5V V <sub>-</sub> =0V to -1V	5	8	11	ms
Output Delay of Release from Excess Charge-current	tV <sub>REL4</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.5V, V <sub>C</sub> -V <sub>SS</sub> =3.5V V <sub>-</sub> =-1V to 0V	0.7	1.2	1.7	ms
Delay Shortening Mode Voltage	V <sub>DS</sub>	V <sub>DD</sub> -V <sub>C</sub> =4.4V, V <sub>C</sub> -V <sub>SS</sub> =4.4V	-2.2	-1.6	-1.0	V
Nch ON-Voltage of C <sub>OUT</sub>	V <sub>OL1</sub>	I <sub>ol</sub> =50μA, V <sub>DD</sub> -V <sub>C</sub> =4.5V V <sub>C</sub> -V <sub>SS</sub> =4.5V		0.4	0.5	V
Pch ON-Voltage of C <sub>OUT</sub>	V <sub>OH1</sub>	I <sub>oh</sub> =-50μA, V <sub>DD</sub> -V <sub>C</sub> =3.9V V <sub>C</sub> -V <sub>SS</sub> =3.9V	6.8	7.4		V
Nch ON-Voltage of D <sub>OUT</sub>	V <sub>OL2</sub>	I <sub>ol</sub> =50μA, V <sub>DD</sub> -V <sub>C</sub> =1.9V V <sub>C</sub> -V <sub>SS</sub> =1.9V		0.2	0.5	V
Pch ON-Voltage of D <sub>OUT</sub>	V <sub>OH2</sub>	I <sub>oh</sub> =-50μA, V <sub>DD</sub> -V <sub>C</sub> =3.9V V <sub>C</sub> -V <sub>SS</sub> =3.9V	6.8	7.4		V
Supply Current	I <sub>DD</sub>	V <sub>DD</sub> -V <sub>C</sub> =3.9V, V <sub>C</sub> -V <sub>SS</sub> =3.9V V <sub>-</sub> =0V		4.0	8.0	μA
Standby Current	I <sub>STB</sub>	V <sub>DD</sub> -V <sub>C</sub> =1.9V, V <sub>C</sub> -V <sub>SS</sub> =1.9V			0.1	μA

\*Note1: Considering of variation in process parameters, we compensate for this characteristic related to temperature by laser-trim, however, this specification is guaranteed by design, not tested.

## **OPERATION**

### **• VDET1U, VDET1L / Over-Charge Detectors**

The VDET1U and VDET1L monitor the voltage between  $V_{DD}$  pin and  $V_C$  pin (the voltage of Cell1) and the voltage between  $V_C$  pin and  $V_{SS}$  pin (the voltage of Cell2), if either voltage becomes equal or more than the over-charge detector threshold, the over-charge is detected, and an external charge control Nch MOSFET turns off with  $C_{OUT}$  pin being at "L" level.

VDET1U is the detector of Cell1, and the VDET1L is the detector of Cell2.

To reset the over-charge and make the  $C_{OUT}$  pin level to "H" again after detecting over-charge, in such conditions that a time when the both Cell1 and Cell2 are down to a level lower than over-charge voltage, by connecting a kind of load to  $V_{DD}$  after disconnecting a charger from the battery pack. Then, the output voltage of  $C_{OUT}$  pin becomes "H", and it makes an external Nch MOSFET turn on, and charge cycle is available. In case of the charger is continuously connected and over-charge is detected, both battery voltages of Cell1 and Cell2 become lower than the released voltage from over-charge, charge becomes possible. Therefore there is a specific hysteresis for over-charge detectors. To judge whether or not load is connected, the built-in excess-discharge current detector is used. By connecting some load,  $V_-$  pin voltage becomes equal or more than excess-discharge current detector threshold, and reset the over-charge detecting state.

Further, either or both voltage of Cell1 and Cell2 is higher than the over-charge detector threshold, if a charger is removed and some load is connected,  $C_{OUT}$  outputs "L", however, load current can flow through the parasitic diode of the external charge control Nch MOSFET. After that, when both voltages of Cell1 and Cell2 become lower than the over-charge detector threshold,  $C_{OUT}$  becomes "H".

Internal fixed output delay times for over-charge detection and release from over-charge exist. If either or both of the voltage of Cell1 or Cell2 keeps its level more than the over-charge detector threshold, and output delay time passes, over-charge voltage is detected. Even when the voltage of Cell1 or Cell2 pin level becomes equal or higher level than  $V_{DET1}$  if these voltages would be back to a level lower than the over-charge detector threshold within a time period of the output delay time, the over-charge is not detected. Besides, after detecting over-charge, while the both of Cell1 and Cell2 voltages are lower than the over-charge detector threshold, even if a charger is removed and a load is connected, if the voltage is recovered within output delay time of release from over-charge, over-charge state is not released.

A level shifter incorporated in a buffer driver for the  $C_{OUT}$  pin makes the "L" level of  $C_{OUT}$  pin to the  $V_-$  pin voltage and the "H" level of  $C_{OUT}$  pin is set to  $V_{DD}$  voltage with CMOS buffer.

### **• VDET2U, VDET2L / Over-Discharge Detectors**

The VDET2U and VDET2L monitor the voltage between  $V_{DD}$  pin and  $V_C$  pin (Cell1 voltage) and the voltage between  $V_C$  pin and  $V_{SS}$  pin (Cell2 Voltage). When either of the Cell1 or Cell2 voltage becomes equal or less than the over-discharge detector threshold, the over-discharge is detected and discharge stops by the external discharge control Nch MOSFET turning off with the  $D_{OUT}$  pin being at "L" level.

To reset the over-discharge detector, connecting a charger is the only method. When the charger is connected,

---



if Cell1 or Cell2 is less than the over-discharge detector threshold, a charge current flows through the parasitic diode of the external MOSFET. Then, the voltages of Cell1 and Cell2 become higher than the released voltage from over-discharge,  $D_{OUT}$  becomes "H" and the external MOSFET turns on and discharge will be possible. When a charger is connected, when the Cell1 and Cell2 voltages become equal or more than the over-discharge detector threshold, the over-discharge is released and the voltage of the  $D_{OUT}$  pin becomes "H" after the delay time.

When either Cell1 or Cell2 voltage is equal or less than the maximum voltage for inhibition of charger ( $V_{nochg}$ ), even if a charger is connected to the battery pack,  $C_{OUT}$  pin is stacked with "L" and the system is not allowable for charge.

The output delay time for over-discharge detect is fixed internally. Even if the voltage of Cell1 or Cell2 is down to equal or lower than the over-discharge detector threshold, if the both voltages of Cell1 and Cell2 would be back to a level higher than the over-discharge detector threshold within a time period of the output delay time, the over-discharge is not detected. Output delay time for release from over-discharge is also set.

After detecting over-discharge, supply current would be reduced and be into standby by halting all the circuits and consumption current of the IC itself is made extremely low.

The output type of  $D_{OUT}$  pin is CMOS having "H" level of  $V_{DD}$  and "L" level of  $V_{SS}$ .

- **VDET3 /Excess discharge-current Detector, Short Circuit Protector**

Both of the excess current detector and short circuit protection can work when the both of control FETs are in "ON" state.

When the V- pin voltage is up to a value between the short protection voltage  $V_{short}$  and excess discharge-current threshold  $V_{DET3}$ , VDET3 operates and further soaring of V- pin voltage higher than  $V_{short}$  makes the short circuit protector enabled. This leads the external discharge control Nch MOSFET turns off with the  $D_{OUT}$  pin being at "L" level.

An output delay time for the excess discharge-current detector is internally fixed. A quick recovery of V- pin level from a value between  $V_{short}$  and  $V_{DET3}$  within the delay time keeps the discharge control FET staying "H" state. Output delay time for Release from excess discharge-current detection is also set.

When the short circuit protector is enabled, the  $D_{OUT}$  would be "L" and the delay time is also set.

The V - pin has a built-in pull-down resistor to the  $V_{SS}$  pin, that is, the resistance to release from excess-discharge current. After an excess discharge-current or short circuit protection is detected, removing a cause of excess discharge-current or external short circuit makes an external discharge control FET to an "ON" state automatically with the V- pin level being down to the  $V_{SS}$  level through the built-in pulled down resistor. The reset resistor of excess discharge-current is off at normal state. Only when detecting excess discharge-current or short circuit, the resistor is on.

Output delay time of excess discharge-current is set shorter than the delay time for over-discharge detector. Therefore, if  $V_{DD}$  voltage would be lower than  $V_{DET2}$  at the same time as the excess discharge-current is detected, the R5463Kxxxxx is at excess discharge-current detection mode. By disconnecting a load, VDET3 is automatically released from excess discharge-current.

- **VDET4/ Excess charge-current detector**

When the battery pack is chargeable and discharge is also possible, VDET4 senses V- pin voltage. For example, in case that a battery pack is charged by an inappropriate charger, an excess current flows, then the voltage of V- pin becomes equal or less than excess charge-current detector threshold. Then, the output of C<sub>OUT</sub> becomes "L", and prevents from flowing excess current in the circuit by turning off the external Nch MOSFET.

Output delay of excess charge current is internally fixed. Even the voltage level of V- pin becomes equal or lower than the excess charge-current detector threshold, the voltage is higher than the VDET4 threshold within the delay time, the excess charge current is not detected. Output delay for the release from excess charge current is also set.

VDET4 can be released with disconnecting a charger and connecting a load.

- **DS (Delay Shorten) function**

Output delay time of over-charge, over-discharge can be shorter than those setting value by forcing equal or less than the delay shortening mode voltage to V- pin when the C<sub>OUT</sub> is "H".

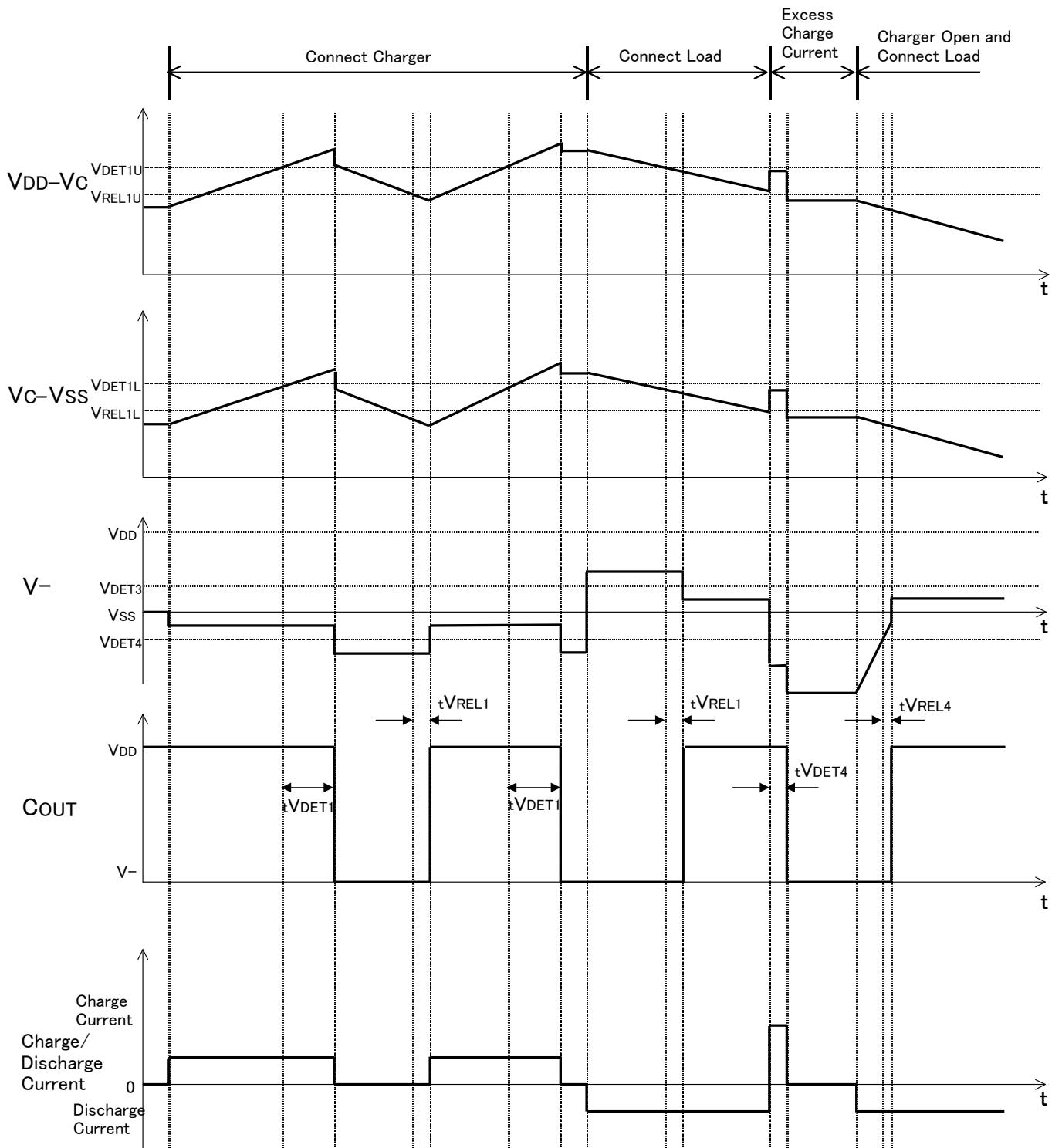
- **Operation against 2-Cell Unbalance**

If one of the cells detects over-charge, and when the C<sub>OUT</sub> becomes "L", even if the other cell would detect over-discharge, the over-charge detector will be dominant and C<sub>OUT</sub> keeps the "L" level. If one of the cells detects the over-discharge, and when the D<sub>OUT</sub> becomes "L", in case that a charger is connected to the battery pack and the other cell detects over-charge, the internal counter will start and after the delay time of over-discharge detector, D<sub>OUT</sub> will become "H". After the delay time of over-charge release from when the internal counter starts, C<sub>OUT</sub> will be "L". If the over-discharge is detected, internal unnecessary circuits will be cut off and the standby mode will be realized. (Standby current Max. 0.1μA)

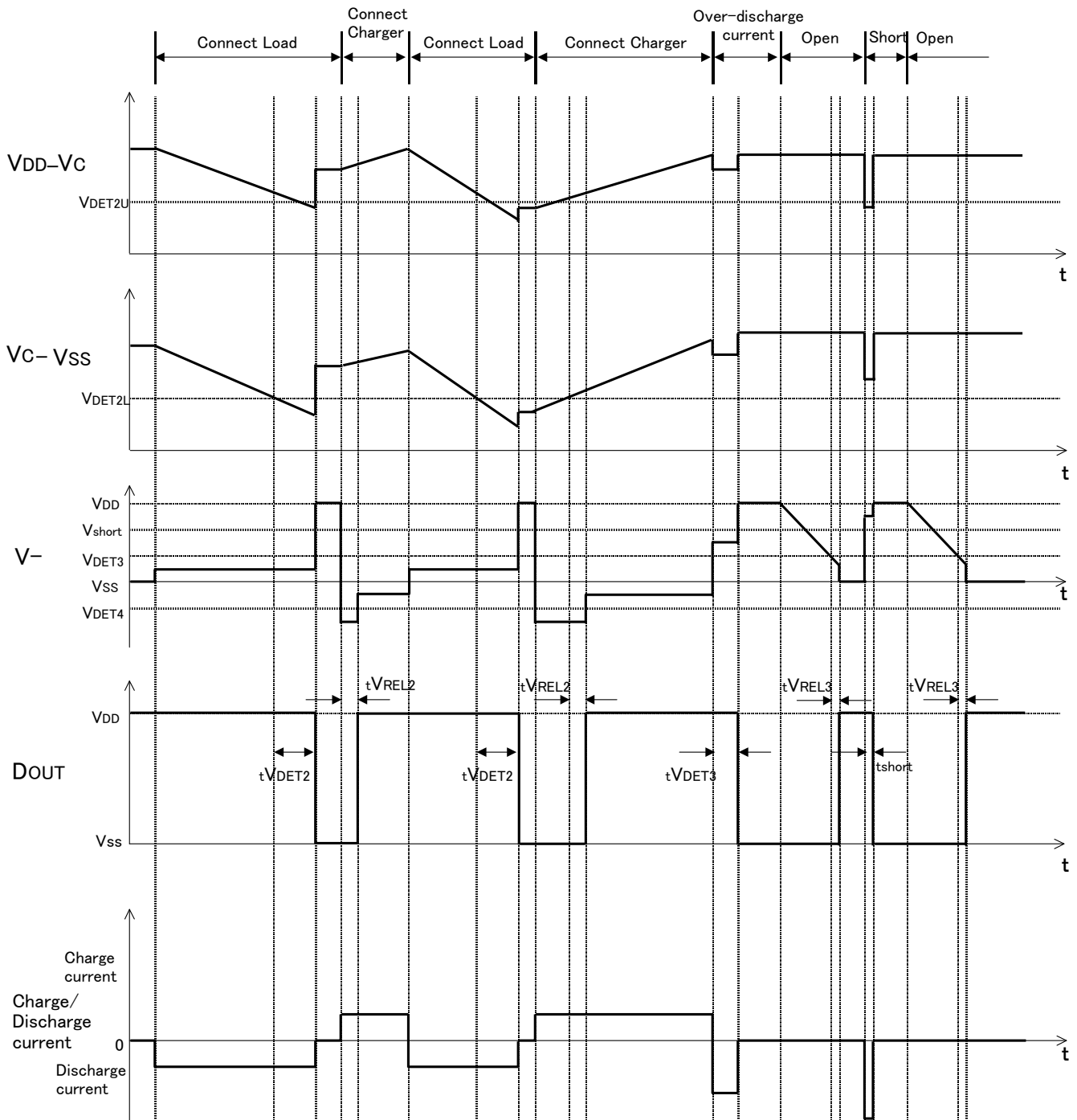
In any versions, the external FETs do not turn off at the same time.

# TIMING CHART

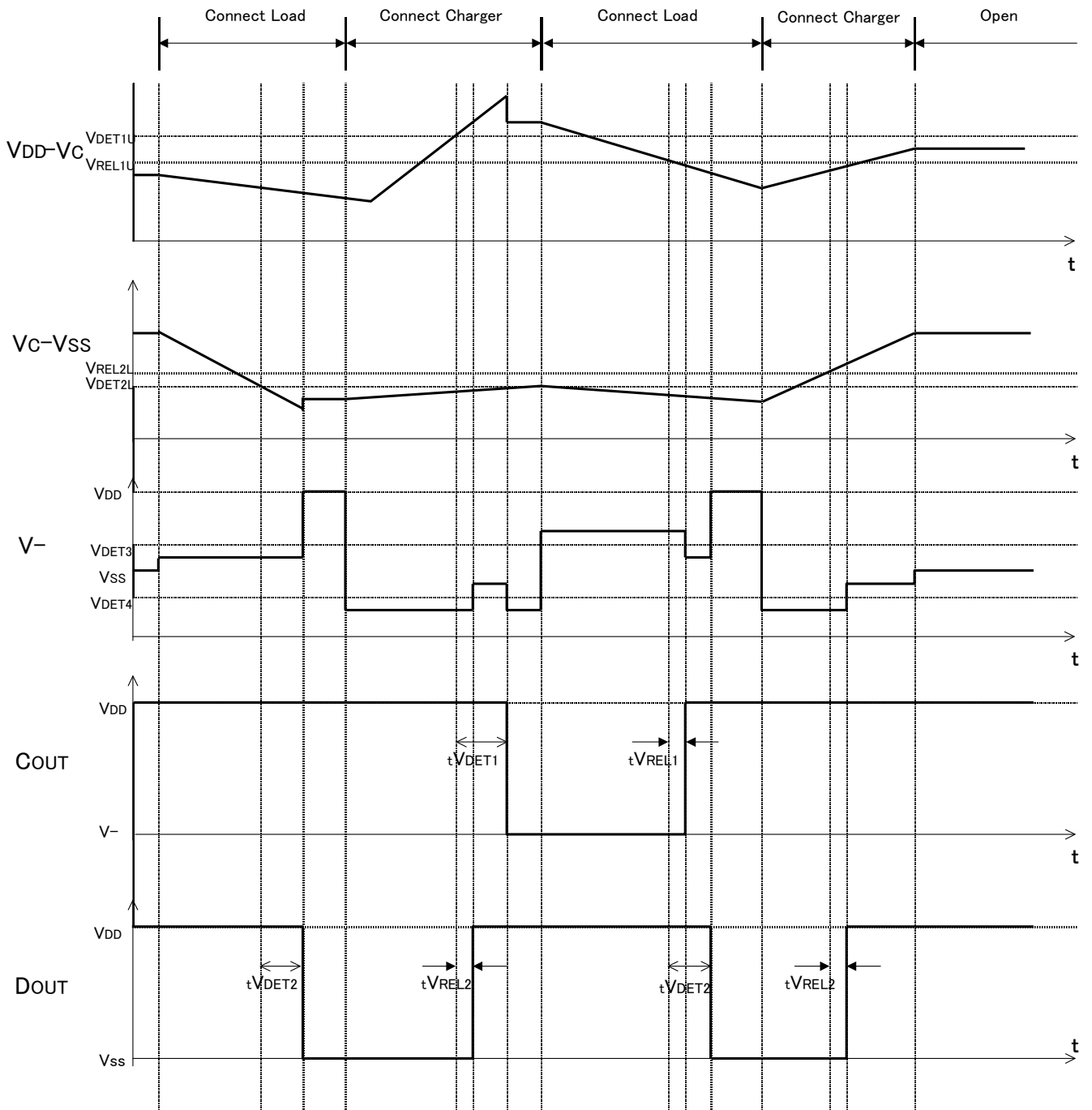
## (1) Timing diagram of Over-charge, Excess charge current



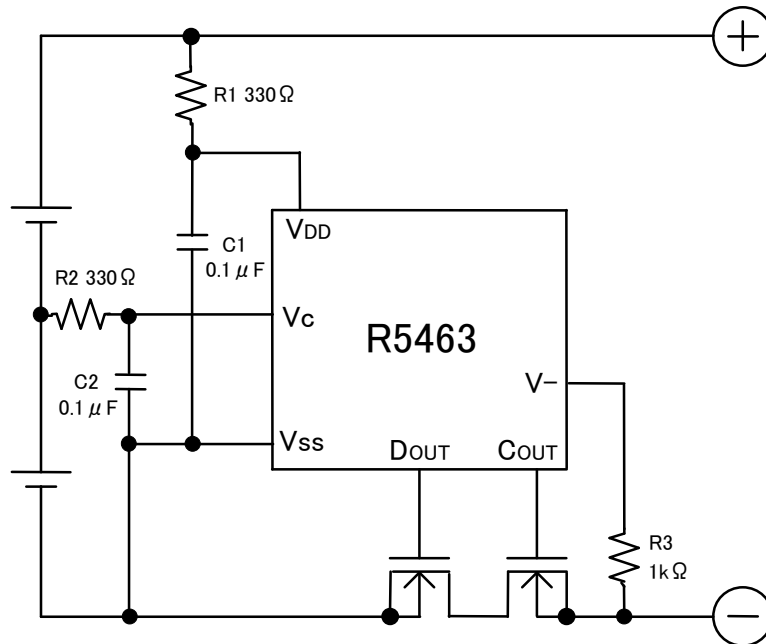
(2) Over-discharge, Excess discharge current, Short circuit



(3) Operation with unbalanced cells



## TYPICAL APPLICATION AND TECHNICAL NOTES



### TECHNICAL NOTES

R1, R2, C1 and C2 stabilize a supply voltage to the R5463. A recommended R1, R2 value is less than 1kΩ. A larger value of R1 and R2 makes the detection voltage shift higher because of some conduction current in the R5463.

To stabilize the operation, the value of C1 and C2 should be equal or more than 0.01μF.

R1 and R3 can operate also as parts for current limit circuit against reverse charge or applying a charger with excess charging voltage beyond the absolute maximum rating of the R5463, the battery pack. Small value of R1 and R3 may cause over-power consumption rating of power dissipation of the R5463. Thus, the total value of 'R1+R3' should be equal or more than 1kΩ. If a large value of R3 is set, after detecting over-discharge, the release by connecting a charger may not be possible. Therefore, recommendation value of R3 is equal or less than 3kΩ.

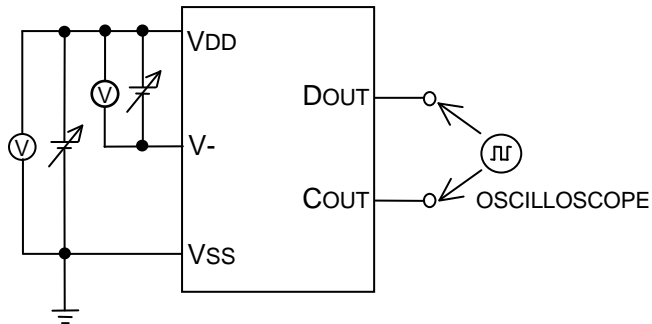
The typical application circuit diagram is just an example. This circuit performance largely depends on the PCB layout and external components. In the actual application, fully evaluation is necessary.

Over-voltage and the over current beyond the absolute maximum rating should not be forced to the protection IC and external components. Although the short protection circuit is built in the IC, if the positive terminal and the negative terminal of the battery pack are short, during the delay time of short limit detector, large current flows through the FET. Select an appropriate FET with large enough current capacity to prevent the IC from burning damage.

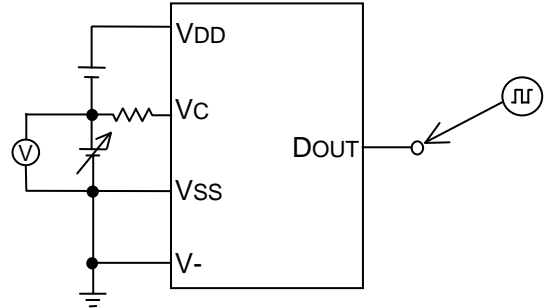
We are making our continuous effort to improve the quality and reliability of our products, but semiconductor products are likely to fail with certain probability. In order prevent any injury to persons or damages to property resulting from such failure, customers should be careful enough to incorporate 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.

# TEST CIRCUITS

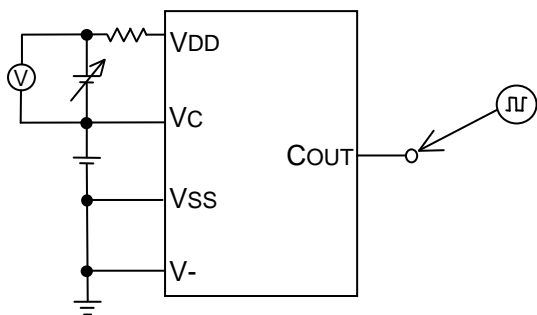
A



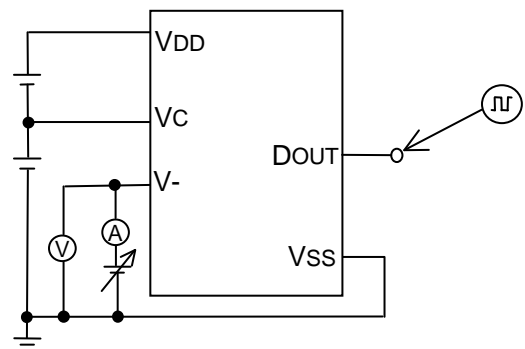
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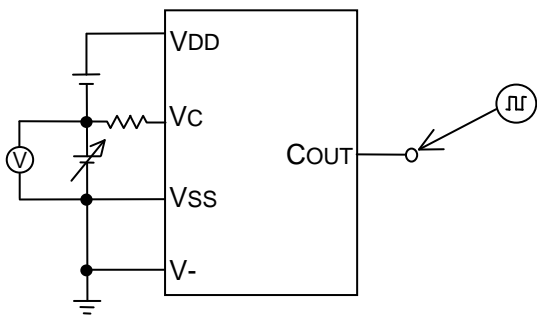
B



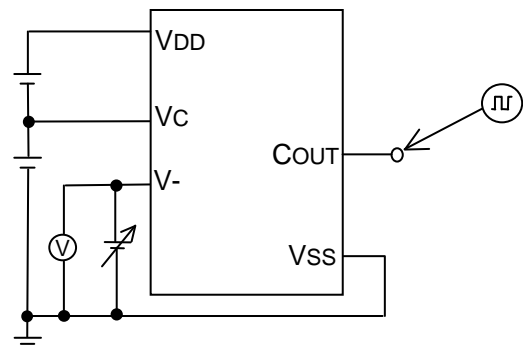
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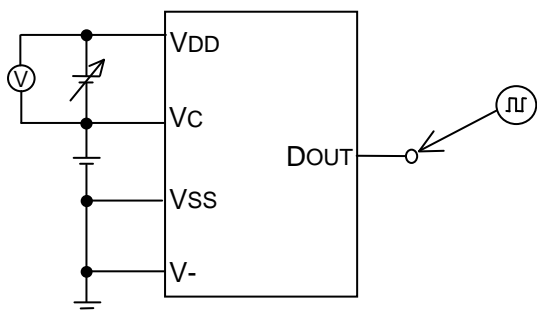
C



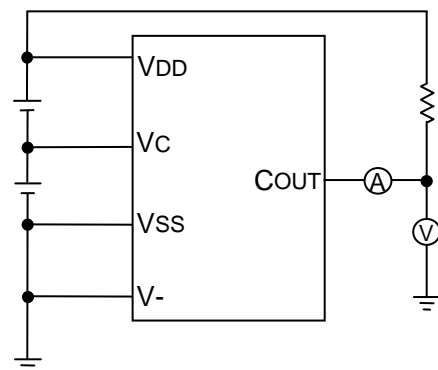
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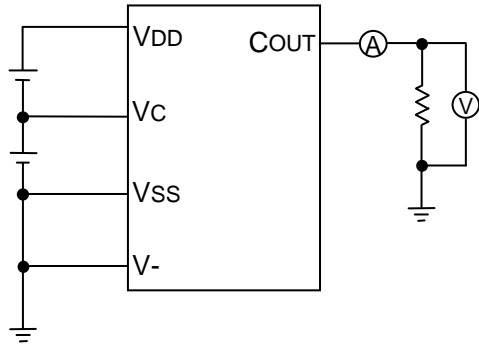
D



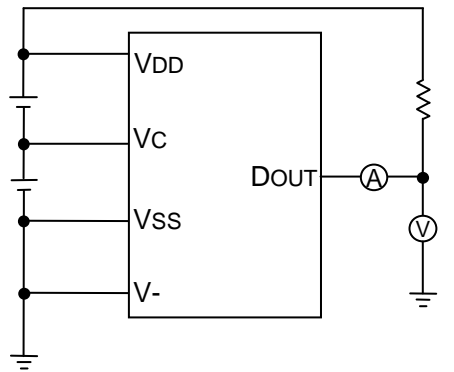
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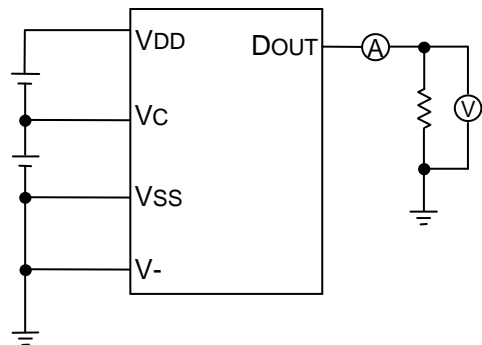
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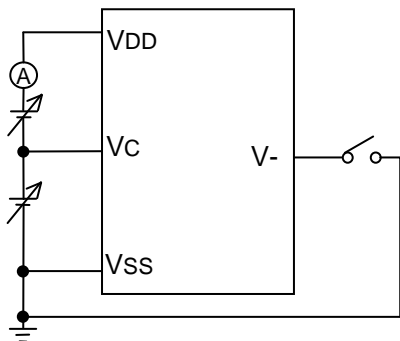
J



K



L



Typical Characteristics were obtained with using those above circuits:

Test Circuit A: Typical characteristics 1)

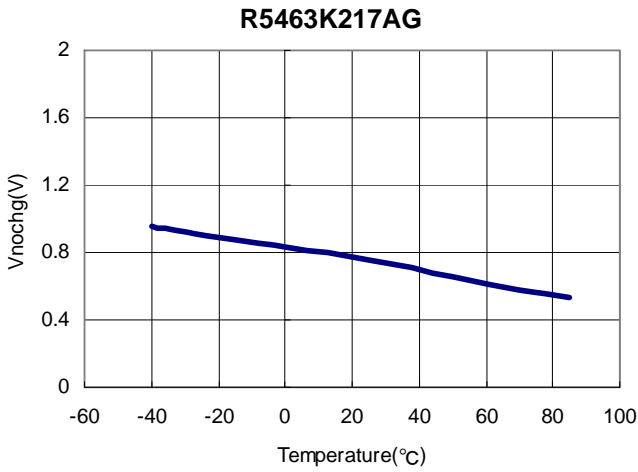


Test Circuit B: Typical characteristics 2) 4) 6) 7)  
Test Circuit C: Typical characteristics 3) 5)  
Test Circuit D: Typical characteristics 8) 10) 11)  
Test Circuit E: Typical characteristics 9)  
Test Circuit F: Typical characteristics 12) 13) 14) 15) 16) 17)  
Test Circuit G: Typical characteristics 18) 19) 20) 21)  
Test Circuit H: Typical characteristics 22)  
Test Circuit I: Typical characteristics 23)  
Test Circuit J: Typical characteristics 24)  
Test Circuit K: Typical characteristics 25)  
Test Circuit L: Typical characteristics 26) 27)

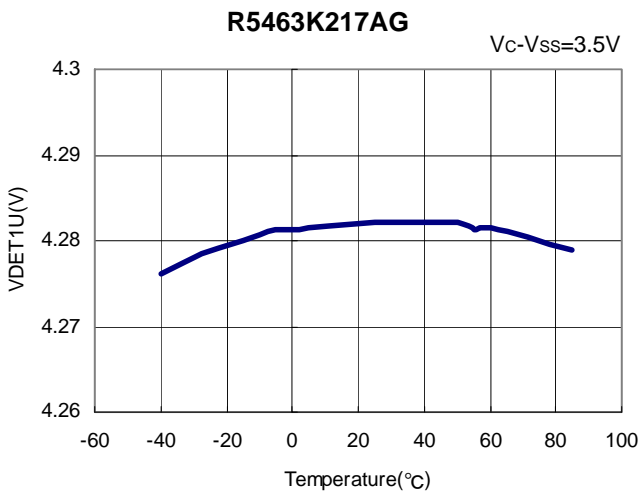
# TYPICAL CHARACTERISTICS

## Part 1

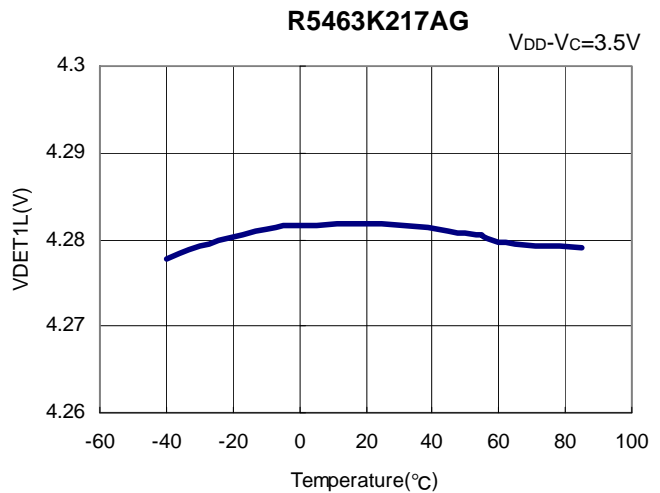
1) Maximum Operating Voltage for Inhibition of Charger vs. Temperature



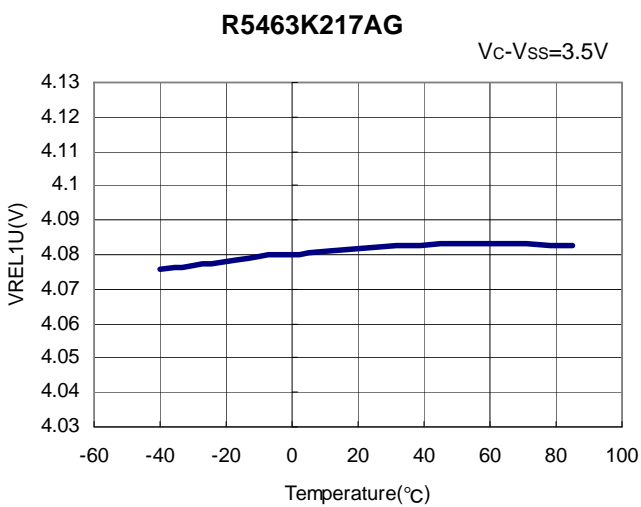
2) Over-charge Detector Threshold (Cell1) vs. Temperature



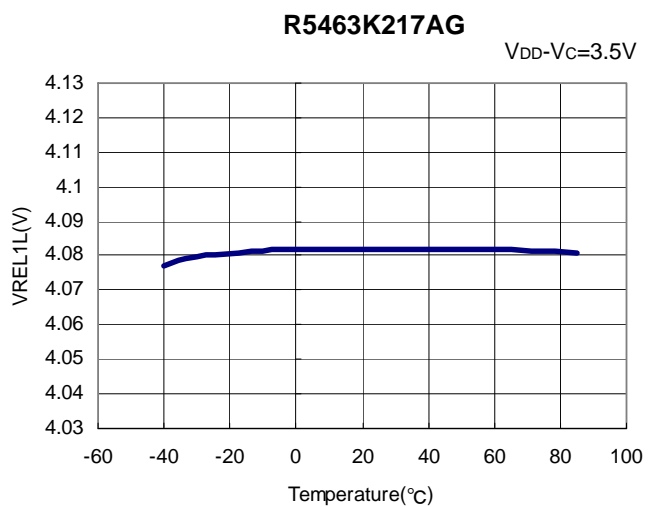
3) Over-charge Detector Threshold (Cell2) vs. Temperature



4) Over-charge Released Voltage (Cell1) vs. Temperature

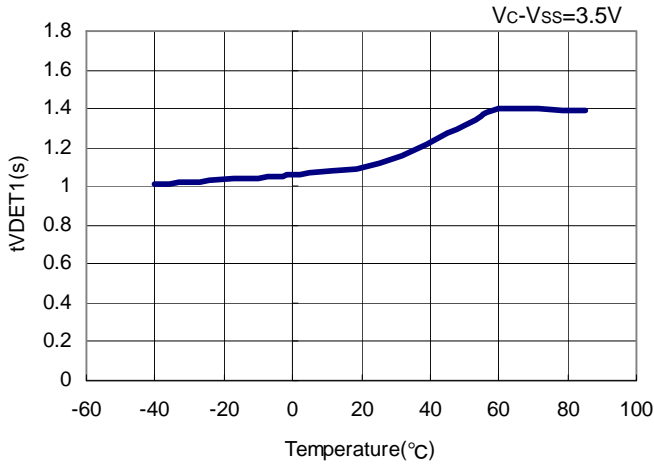


5) Over-charge Released Voltage (Cell2) vs. Temperature



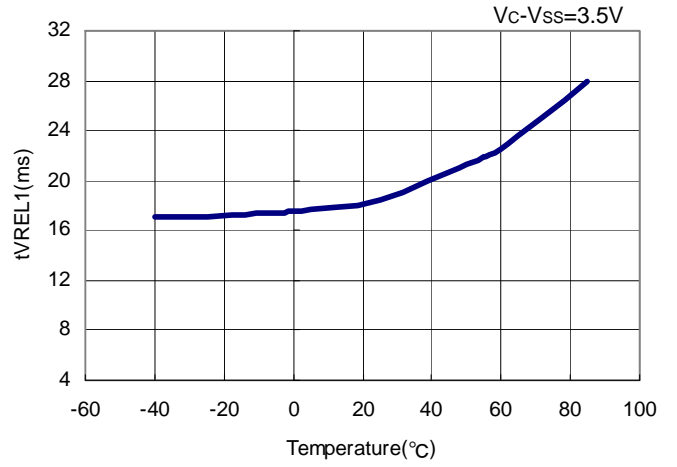
6) Output Delay of Over-charge vs. Temperature

**R5463K217AG**



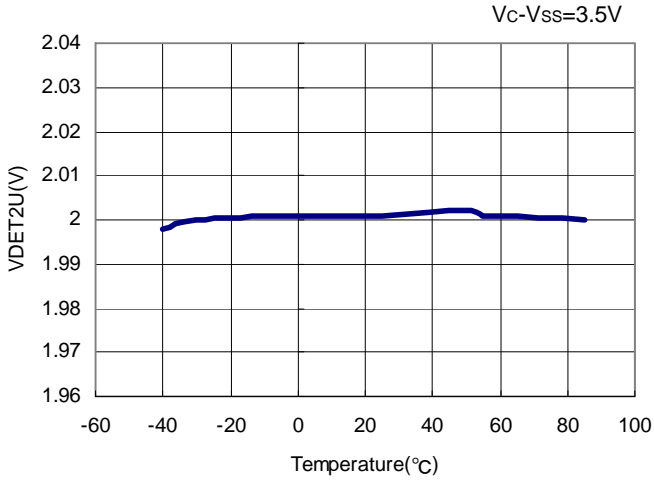
7) Output Delay of Release from Over-charge vs. Temperature

**R5463K217AG**



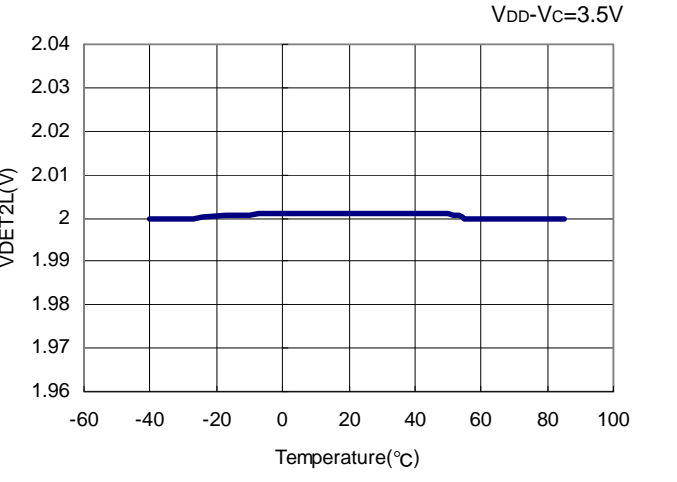
8) Over-discharge Detector Threshold (Cell1) vs. Temperature

**R5463K217AG**



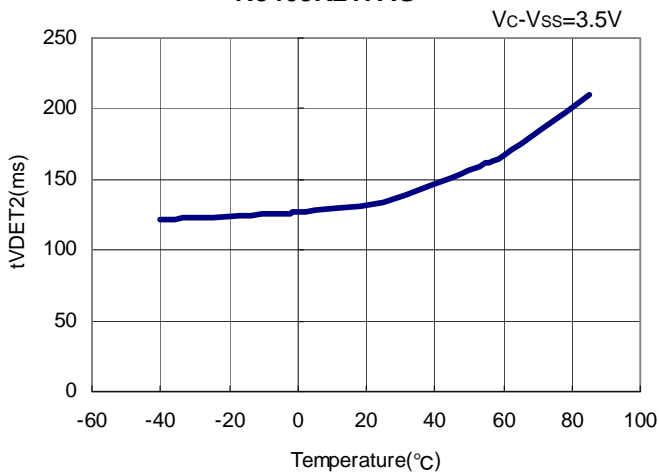
9) Over-discharge Detector Threshold (Cell2) vs. Temperature

**R5463K217AG**



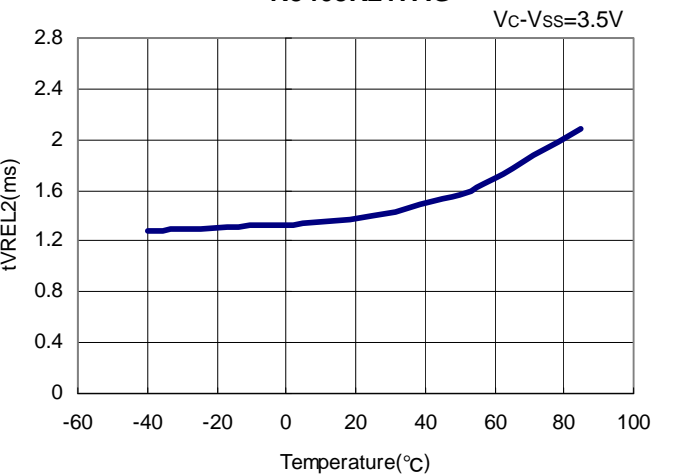
10) Output Delay of Over-discharge vs. Temperature

**R5463K217AG**

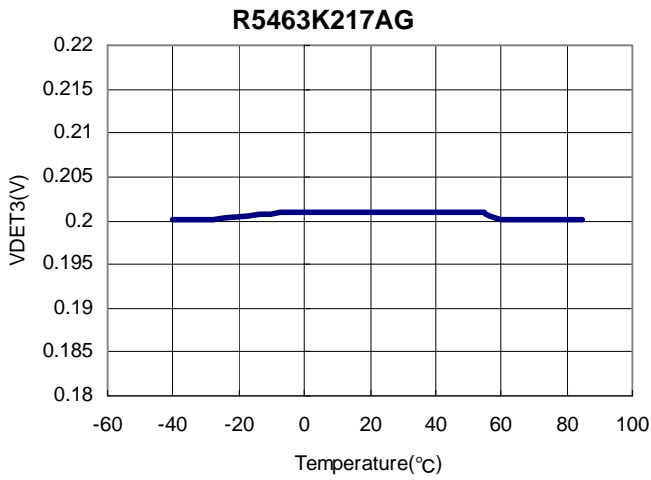


11) Output Delay of Release from Over-discharge vs. Temperature

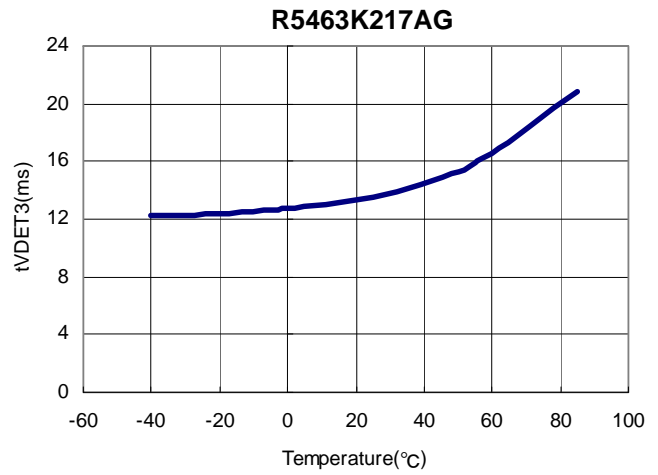
**R5463K217AG**



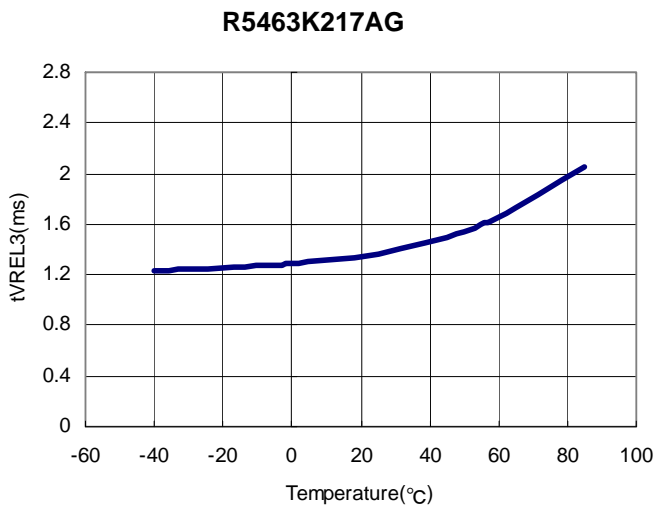
12) Excess Discharge-current Threshold vs. Temperature



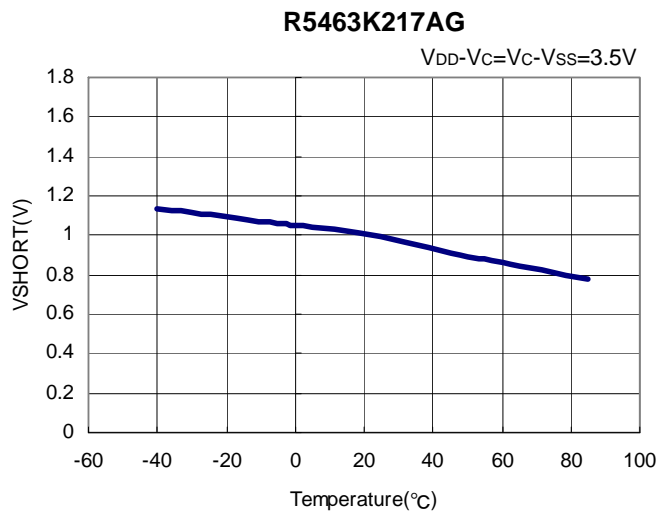
13) Output Delay of Excess Discharge-current vs. Temperature



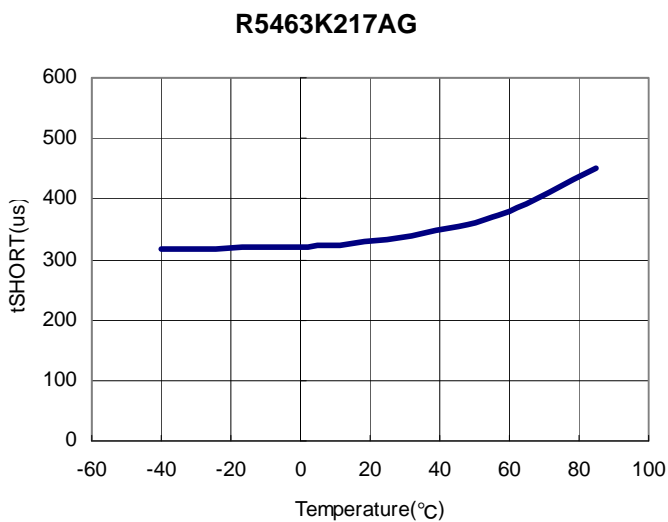
14) Output Delay of Release from Excess Discharge-current vs. Temperature



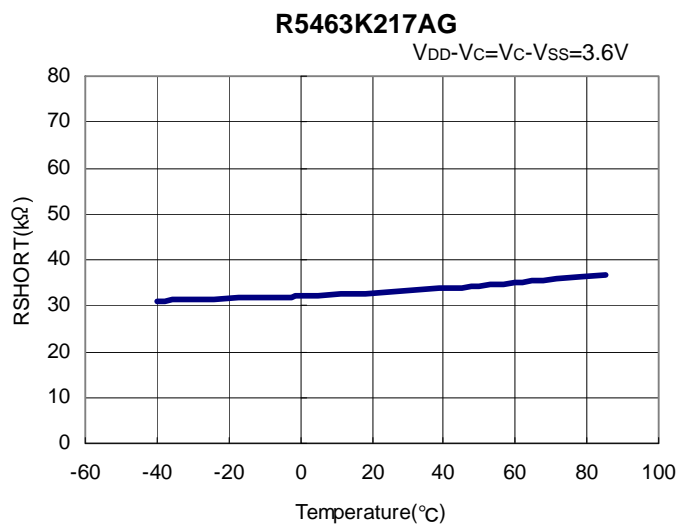
15) Short Protection Voltage vs. Temperature



16) Delay Time for Short Protection vs. Temperature

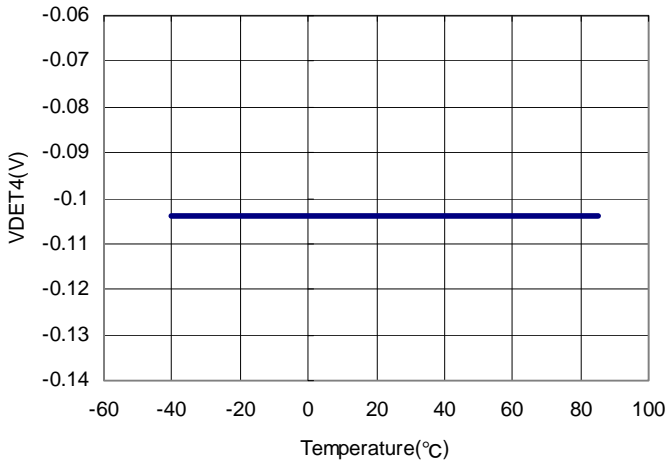


17) Reset Resistance for Excess Current Protection vs. Temperature



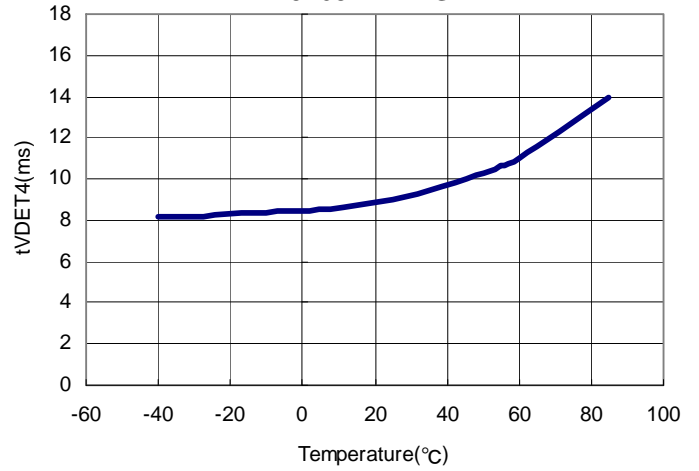
18) Excess Charge-current Threshold vs. Temperature

**R5463K217AG**



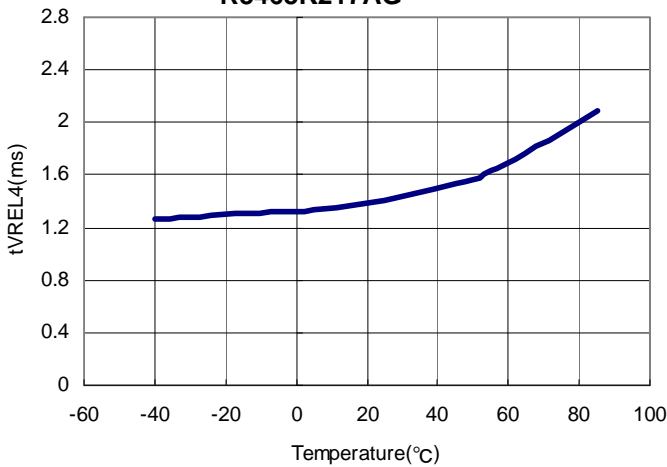
19) Output Delay of Excess Charge-current vs. Temperature

**R5463K217AG**



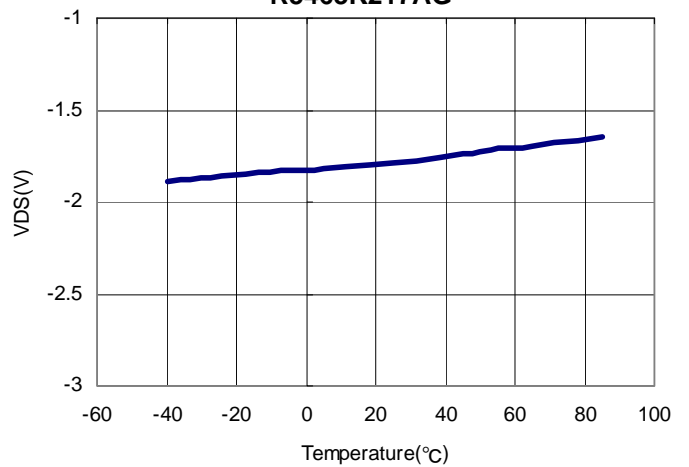
20) Output Delay of Release from Excess Charge-current vs. Temperature

**R5463K217AG**



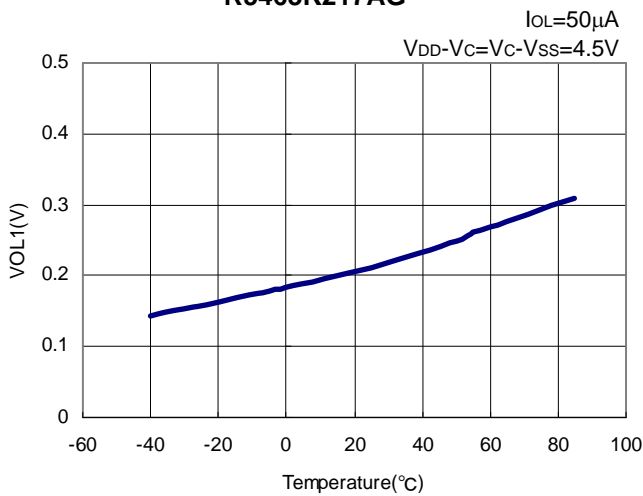
21) Delay Shortening Mode Voltage vs. Temperature

**R5463K217AG**



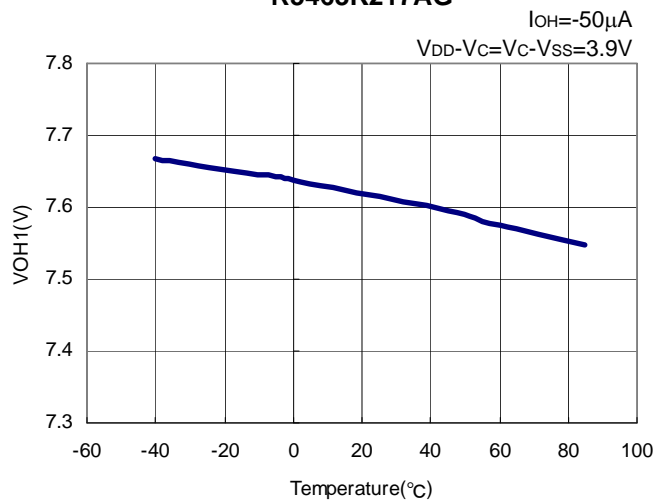
22) Nch ON-Voltage of C<sub>OUT</sub> vs. Temperature

**R5463K217AG**

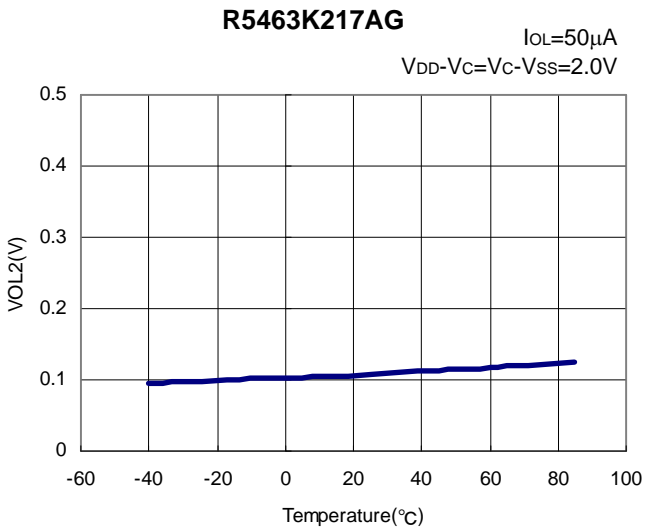


23) Pch ON-Voltage of C<sub>OUT</sub> vs. Temperature

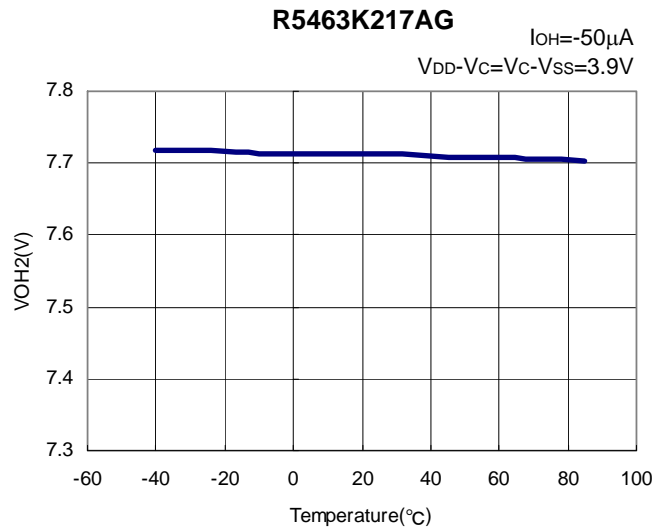
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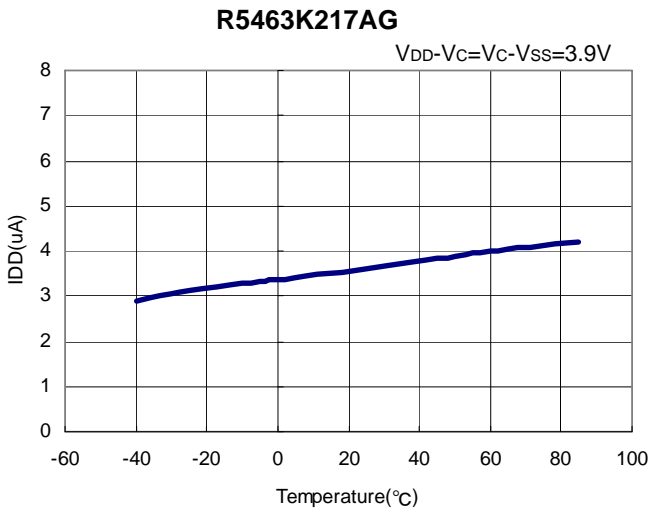
24) Nch ON-Voltage of D<sub>OUT</sub> vs. Temperature



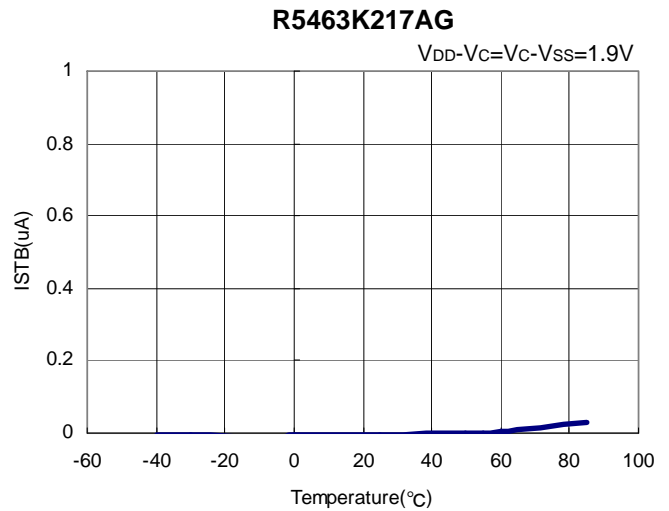
25) Pch ON-Voltage of D<sub>OUT</sub> vs. Temperature



26) Supply Current vs. Temperature

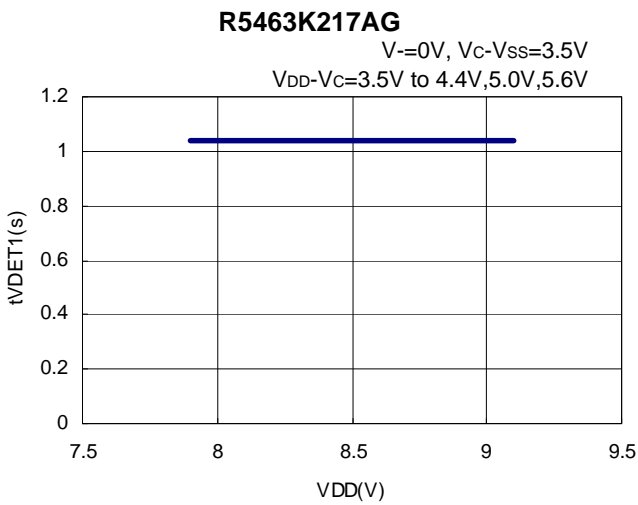


27) Standby Current vs. Temperature

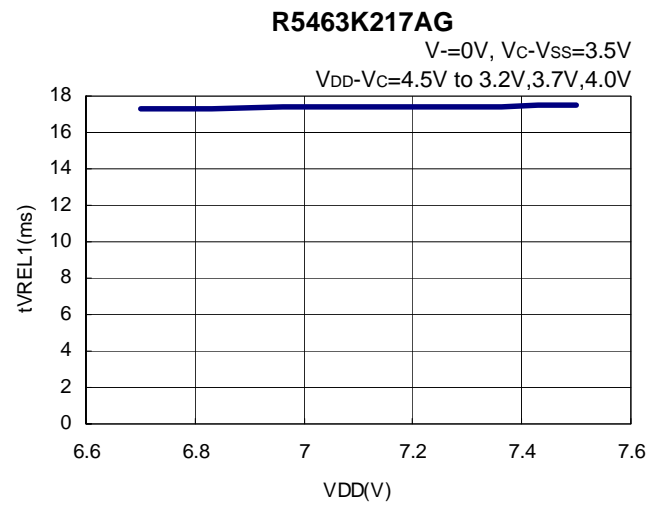


**Part 2 Delay Time dependence on V<sub>DD</sub>**

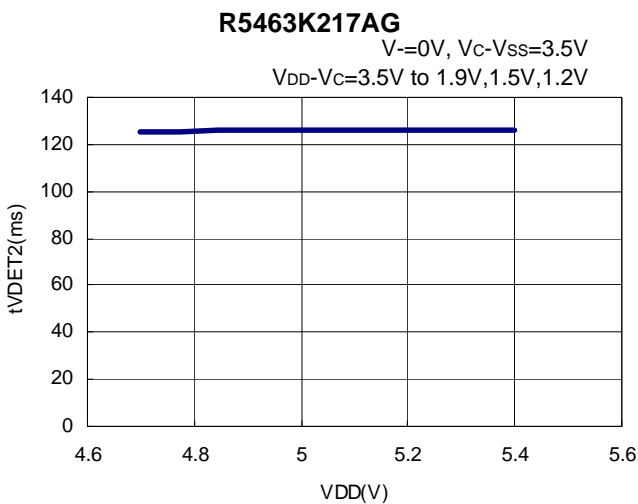
1) Output Delay of Over-charge vs. V<sub>DD</sub>



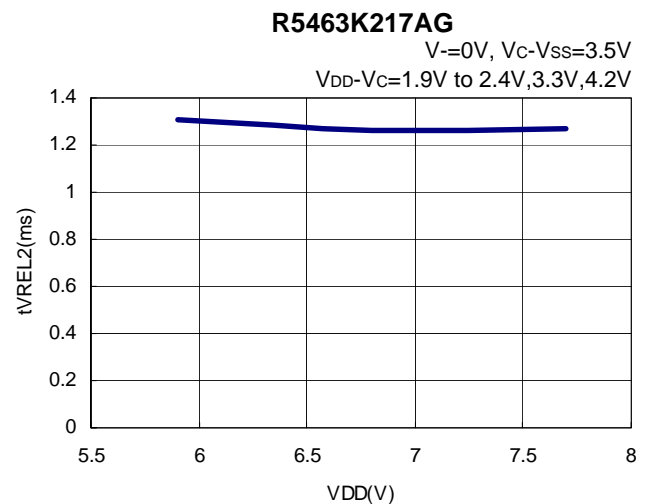
2) Output Delay of Release from Over-charge vs. V<sub>DD</sub>



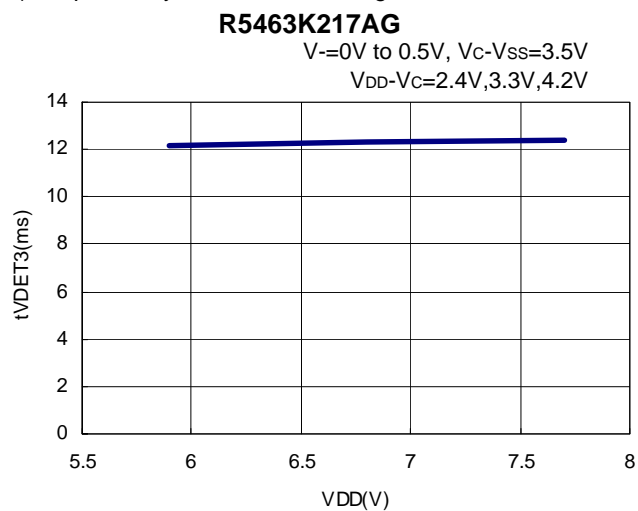
3) Output Delay of Over-discharge vs. V<sub>DD</sub>



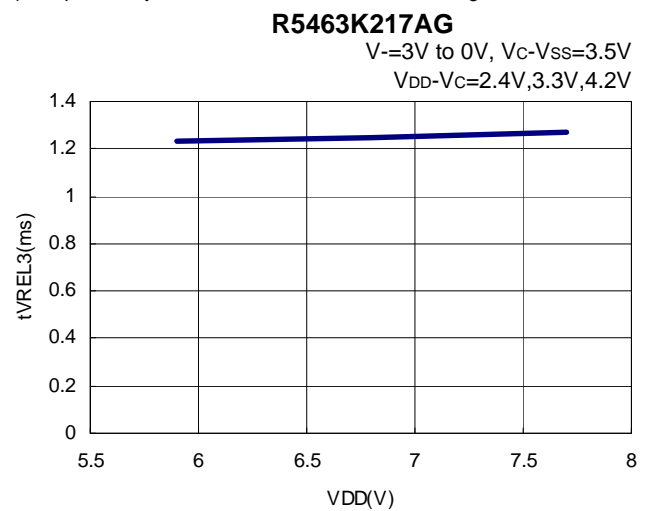
4) Output Delay of Release from Over-discharge vs. V<sub>DD</sub>



5) Output Delay of Excess Discharge-current vs. V<sub>DD</sub>



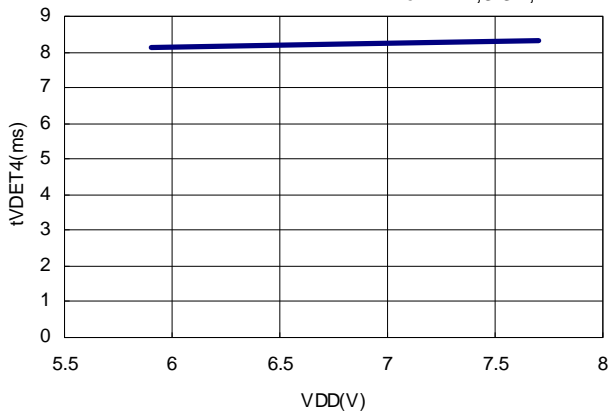
6) Output Delay of Release from Excess Discharge-current vs. V<sub>DD</sub>



7) Output Delay of Excess Charge-current vs.  $V_{DD}$

**R5463K217AG**

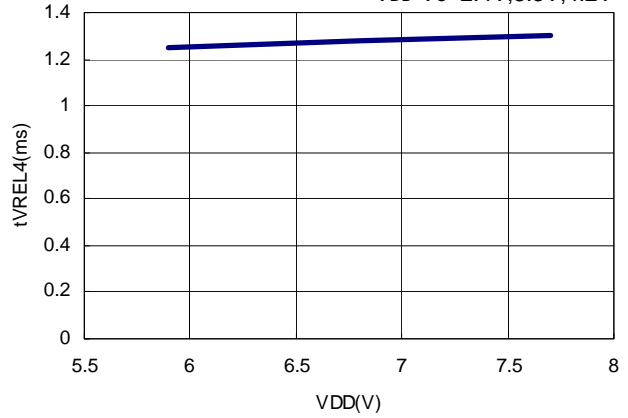
$V_{-}=0V$  to  $-0.9V$ ,  $V_C-V_{SS}=3.5V$   
 $V_{DD}-V_C=2.4V, 3.3V, 4.2V$



8) Output Delay of Release from Excess Charge-current vs.  $V_{DD}$

**R5463K217AG**

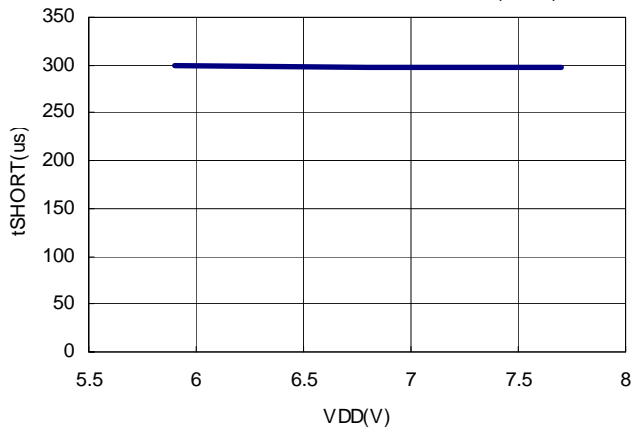
$V_{-}=-0.9V$  to  $0V$ ,  $V_C-V_{SS}=3.5V$   
 $V_{DD}-V_C=2.4V, 3.3V, 4.2V$



9) Delay Time for Short Protection vs.  $V_{DD}$

**R5463K217AG**

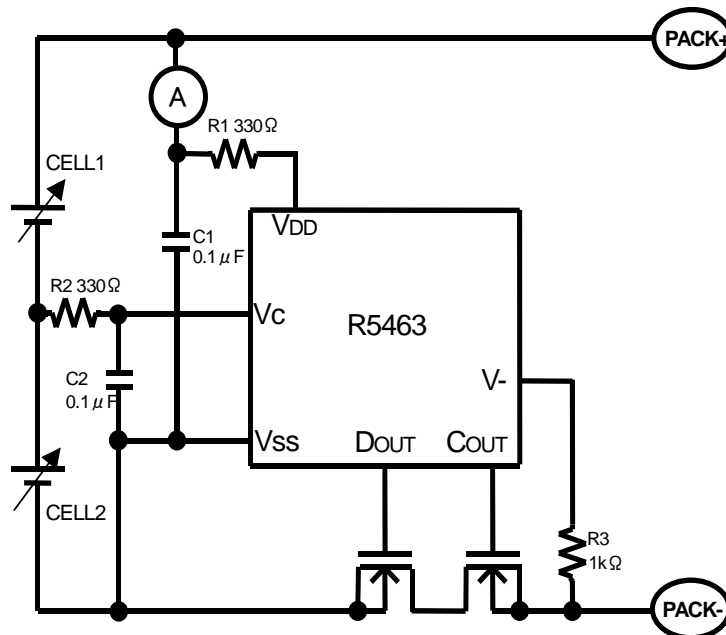
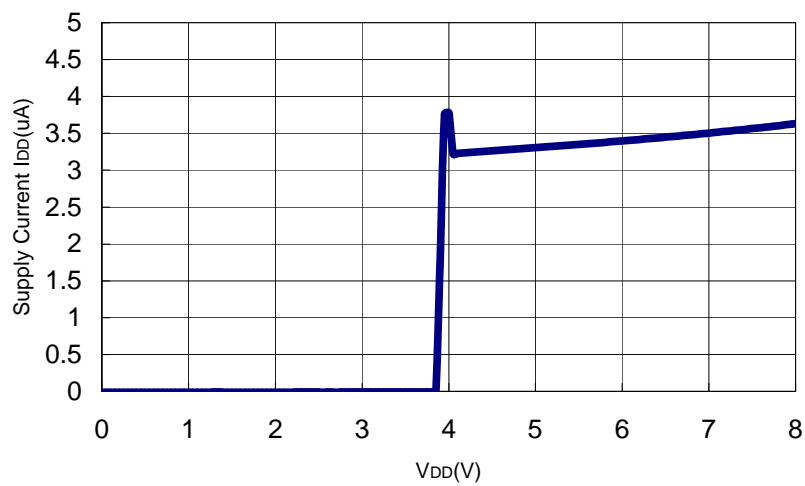
$V_{-}=0V$  to  $1.5V$ ,  $V_C-V_{SS}=3.5V$   
 $V_{DD}-V_C=2.4V, 3.3V, 4.2V$



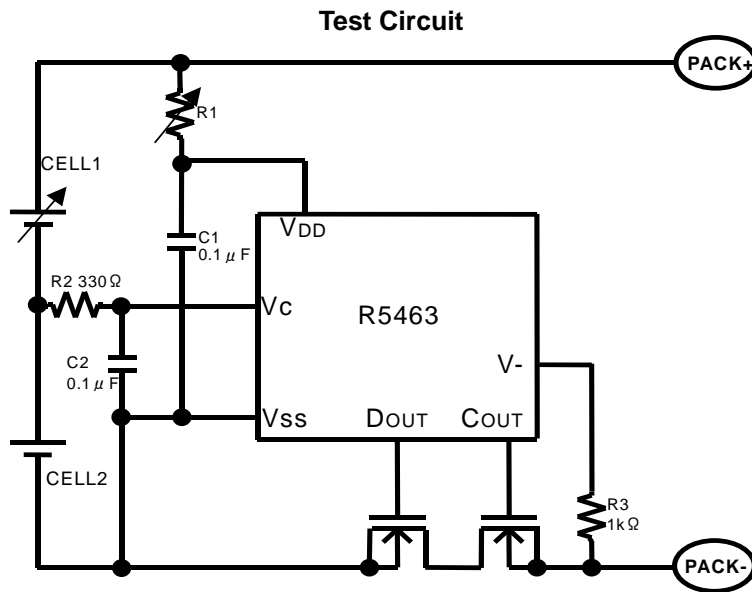


Part 3 Supply Current dependence on  $V_{DD}$ 

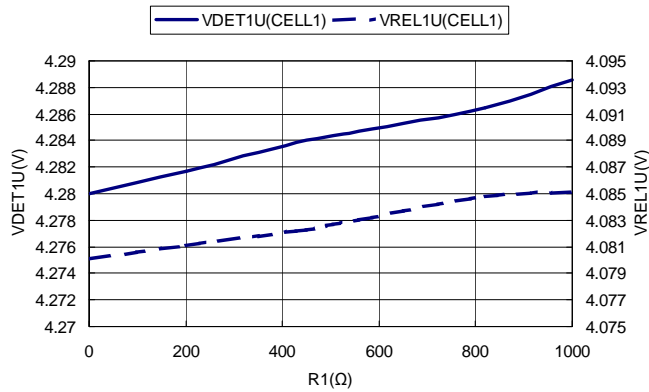
Test Circuit

Supply Current vs.  $V_{DD}$ 

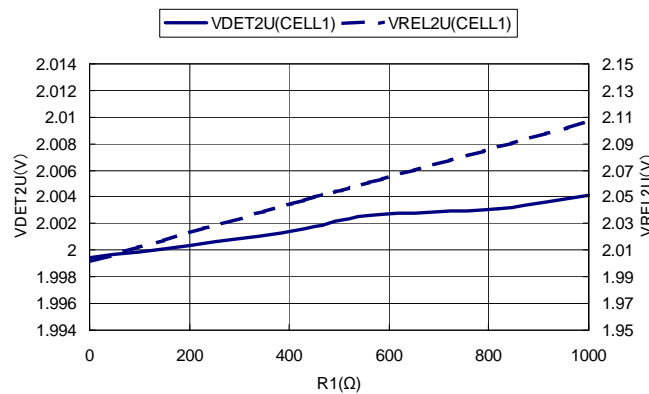
**Part 4 Over-charge detector, Release voltage from Over-charge, Over-discharge detector, Release voltage from Over-discharge dependence on External Resistance value**



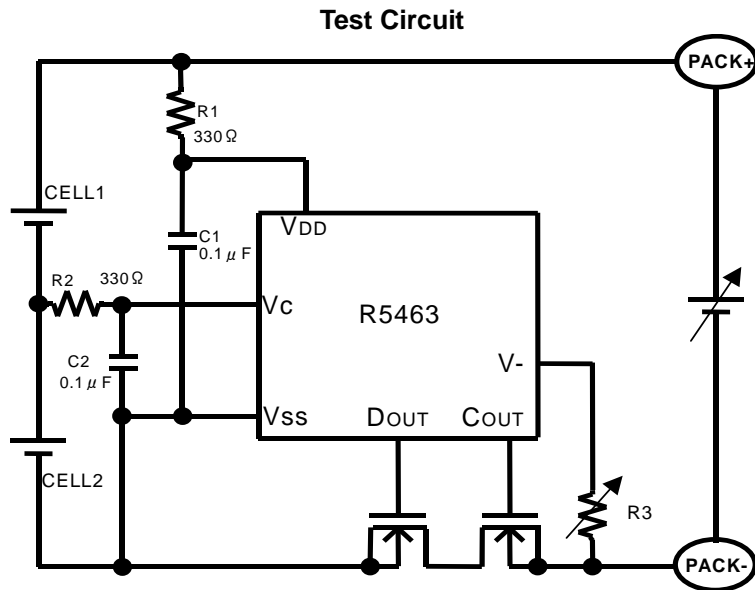
**Over-charge Detector Threshold / Released Voltage from Over-charge vs. R1**  
**R5463K217AG**



**Over-discharge Detector Threshold / Released from Over-discharge Threshold vs. R1**  
**R5463K217AG**



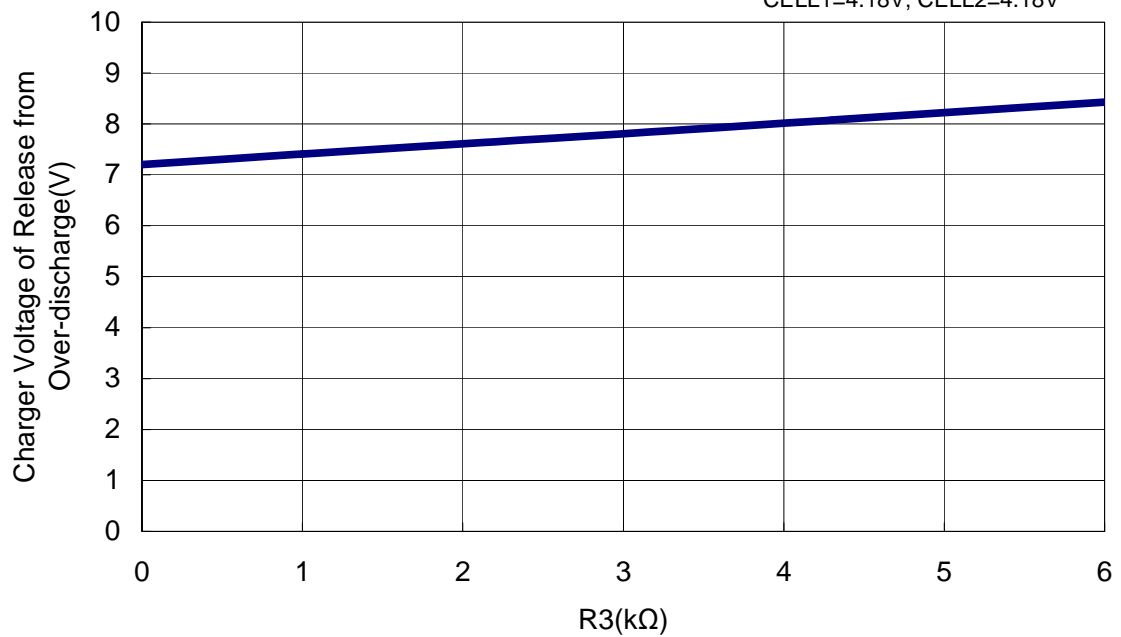
Part 5 Charger Voltage at Released from Over-discharge with a Charger dependence on R2



Charger Voltage at Release from Over-discharge with a charger vs. R2

R5463K217AG

CELL1=4.18V, CELL2=4.18V





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