High Accuracy 2-Cell Li-ion Battery Protection IC with Alarm Function

NO.EA-282-240322

OUTLINE

The R5464K is an overcharge/ overdischarge protector for 2-cell Li-ion batteries that can produce a high-accuracy alarm-signal. The R5464K has an alarm signal output, a temperature detection, an overcharge voltage detection, an overdischarge voltage/ discharge overcurrent detection and a charge overcurrent detection.

The R5464K is composed of eight voltage detectors, a temperature detector, a reference unit, a delay circuit, a short circuit protector, an oscillator, a counter, and a logic circuit. When the over-charge voltage or overcharge current is detected, the battery voltage crosses the each detector threshold, the output of COUT pin switches to “L” level after internal fixed delay time. To release overcharge or charge overcurrent detector, after detecting overcharge, or charge overcurrent, the detector will be released and the output of COUT becomes "H" when a kind of load is connected to VDD after a charger is disconnected from the battery pack and the cell voltage becomes lower than overcharge detector threshold. Even if a charger is continuously connected to the battery pack, when the cell voltage becomes lower than the overcharge detector released voltage, overcharge state is released.

The output of DOUT pin, the output of the overdischarge detector and the discharge overcurrent detector, switches to “L” level after internally fixed delay time, when discharged voltage crosses the detector threshold. To release overdischarge detector, after detecting overdischarge voltage, connect a charger to the battery pack, and when the battery supply voltage becomes higher than the over-discharge detector threshold, the overdischarge detector is released and the output of DOUT becomes "H".

When the overcharge alarm is detected, after the internal fixed delay time, the output of AOUT becomes "H" from high impedance at normal state. Further, with an external thermistor, if the temperature is 45°C or more, the overcharge alarm detector threshold shifts from normal temperature alarm detector threshold to the high temperature alarm detector threshold. To release the overcharge alarm detector, when the battery voltage becomes lower than the released voltage from overcharge alarm, the output of AOUT becomes from "H" to high impedance. When the thermistor detect temperature becomes lower than 40°C, and cell voltage is equal or lower than the alarm detector threshold at normal temperature, the output of AOUT becomes "H" from high impedance.

After detecting discharge overcurrent or short current, when the load is disconnected, the discharge overcurrent condition or short condition is released and DOUT becomes “H”.

After detecting overdischarge voltage, the supply current will be kept extremely low by halting internal circuits' operation.

When the output of COUT is “H”, if V− pin level is set at typically equal or lower than −1.6 V, the delay time of detectors can be shortened. Especially, the delay time of the over-charge detector and overdischarge detector can be reduced into approximately 1/ 60 and the test time for protection circuit of PCB can be reduced. The output type of COUT and DOUT is CMOS. The output type of AOUT is Pch open drain.

FEATURES

- High-withstand Voltage Process
  - Absolute Maximum Rating ·································30 V
- Low Consumption Current
  - Active Mode ·· Typ. 6.0 μA (AD/ DD Ver.), Typ. 5.0 μA (CG Ver.),
  - Standby Mode·· Max. 0.1 μA
- High-accuracy Voltage Detection
  - Alarm Detection Accuracy ······························ +10 mV/ −15 mV (0°C to 60°C)
  - Overcharge Detection Accuracy ······················ +10 mV/ −15 mV (0°C to 50°C)
  - Overdischarge Detection Accuracy··················· ±2.5%
  - Discharge Overcurrent Detection Accuracy ········ ±15 mV
  - Charge Overcurrent Detection Accuracy············ ±20 mV
- Selectable Detection Voltage
  - Alarm Detection Voltage (Normal Temp.)·········· 3.2 V to 4.4 V, 0.005 V step
  - Difference in Alarm Detection Voltage··············· −0 V to −0.150 V, 0.005 V step
    (Normal Temp - High Temp.)
  - Overcharge Detection Voltage ························ 3.6 V to 4.5 V, 0.005 V step
  - Overdischarge Detection Voltage····················· 2.0 V to 3.0 V, 0.005 V step
  - Discharge Overcurrent Detection Voltage ·········· 0.05 V to 0.24 V, 0.005 V step
  - Charge Overcurrent Detection Voltage·············· −0.22 V to −0.1 V, 0.005 V step
  - Alarm Restoration Hysteresis Voltage[1]··················· −0 V to −0.25 V, 0.010 V step
  - Overcharge Restoration Hysteresis Voltage ······· −0 V to −0.25 V, 0.010 V step
  - Short-circuit Detection Voltage ························ 1.0 V, ±0.4 V (Fixed)
- Alarm Detection Switching
  - Alarm Detection Temperature (High)················· 45°C (Fixed)
- Detection Delay Time
  - Alarm Detection (Fixed) ································ Typ. 6 ms (AD/ CG Ver.), Typ. 36 ms (DD Ver.)
  - Overcharge Detection ·································· Typ. 1.0 s
  - Over-discharge Detection······························· Typ. 128 ms
  - Discharge Overcurrent Detection ····················· Typ. 12 ms (AD/ DD Ver.), Typ. 16 ms (CG Ver.)
  - Charge Overcurrent Detection Delay Time········· Typ. 8 ms
  - Short-circuit Detection Delay Time ··················· Typ. 300 μs
- Delay Time Shortening [2]
  - Reduction in Overcharge Detection Delay Time ······ Approximately 1/60
- 0 V Battery Charge Option
- Selectable Hysteresis (5°C) to Alarm Detection Temperature (High)
- Small Package ·· DFN(PL)2527-10

[1] The difference between the alarm detection voltage and the alarm restoration voltage is hysteresis. The hysteresis in normal temperature is set to the same value as the hysteresis in high temperature.
[2] When the output of COUT is “H”, if V−pin level is set at typically equal or lower than −1.6 V, the delay time can be shortened.

APPLICATION

- Overcharge/ Overdischarge/ Overcurrent Protector for 2-Cell Li-ion/ Li-polymer Battery Pack
- Overcharge/ Overdischarge/ Overcurrent Protector for Single Lens Reflex Camera

SELECTION GUIDE

The overcharge, overdischarge, discharge overcurrent, charge overcurrent, 0-V battery charge option and their detection delay times are user-selectable options.

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R5464Kxxx$∗-TR	DFN(PL)2527-10	5,000 pcs	Yes	Yes

xxx: Specify the overcharge alarm detection voltage, overcharge detection voltage, overdischarge detection voltage, discharge current and charge overcurrent.

$: Specify the delay times of overcharge alarm detection voltage (t_{VALM}), overcharge detection voltage (t_{VDET1}), overdischarge detection voltage (t_{VDET2}), discharge overcurrent (t_{VDET3}), and charge overcurrent (t_{VDET4}).

(A) t_{VALM} = 6 ms, t_{VDET1} = 1 s, t_{VDET2} = 128 ms, t_{VDET3} = 12 ms, t_{VDET4} = 8 ms
(C) t_{VALM} = 6 ms, t_{VDET1} = 1 s, t_{VDET2} = 128 ms, t_{VDET3} = 16 ms, t_{VDET4} = 8 ms
(D) t_{VALM} = 36 ms, t_{VDET1} = 1 s, t_{VDET2} = 128 ms, t_{VDET3} = 12 ms, t_{VDET4} = 8 ms

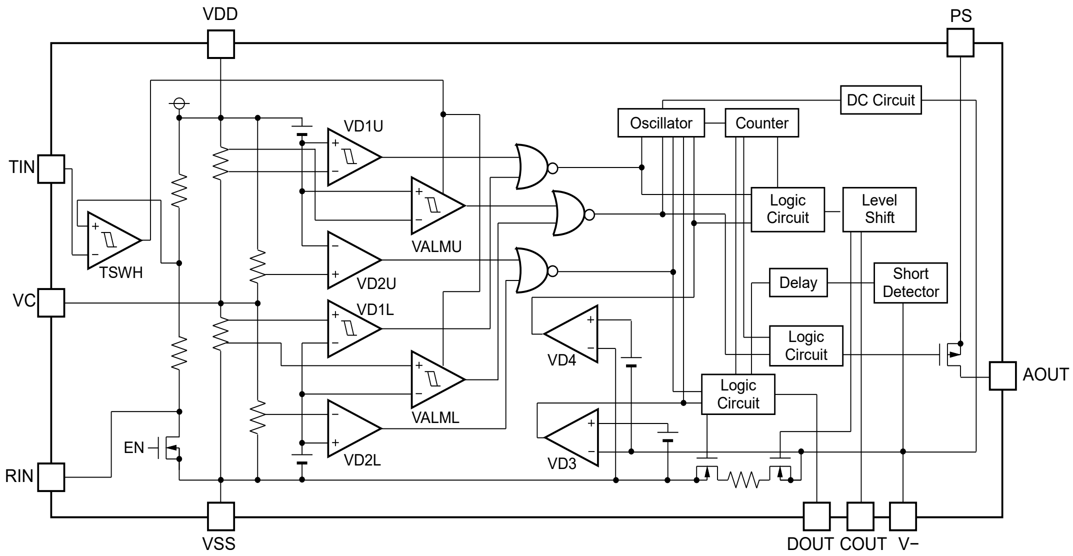
∗: Specify the overcharge restoration method, the overdischarge restoration method, the 0-V battery charge, the high temperature alarm, the normal state of AOUT, the AOUT output circuit type, and the alarm output type.

	Overcharge Restoration Method	Overdischarge Restoration Method	0-V Battery Charge	High Temp. Alarm	Normal State of AOUT	AOUT Output Circuit	Alarm Output Type
D	Automatic	Latch	No	Yes	Open	Pch Open Drain	High/ Open
G	Automatic	Latch	Yes	Yes	High	Pch Open Drain	High/ Open/ Middle

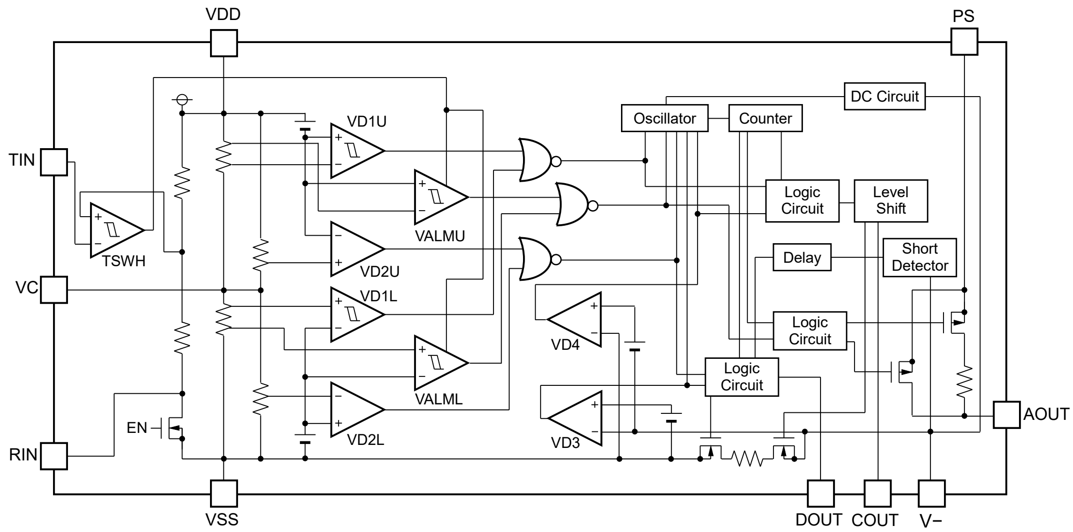
Product Code List

Product Code	V_{DET1} [V]	V_{REL1} [V]	V_{DET2} [V]	V_{DET3} [V]	V_{DET4} [V]	V_{ALM} [V]	V_{RAL} [V]	V_{ALMH} [V]	V_{RALH} [V]	T_{HALM} [°C]	T_{HRAL} [°C]
R5464K**102**CG	4.390	4.190	2.300	0.150	-0.150	4.350	4.350	4.250	4.250	45	45
R5464K**109**CG	4.240	4.040	2.300	0.200	-0.200	4.200	4.200	4.100	4.100	45	40
R5464K**110**CG	4.280	4.080	2.300	0.200	-0.200	4.230	4.230	4.130	4.130	45	45
R5464K**201**AD	4.270	4.100	2.200	0.120	-0.120	4.240	4.050	4.090	3.900	45	40
R5464K**203**AD	4.240	4.100	2.200	0.130	-0.100	4.215	4.165	4.090	4.040	45	40
R5464K**204**AD	4.270	4.100	2.200	0.120	-0.120	4.240	4.230	4.090	4.080	45	40
R5464K**205**AD	4.270	4.100	2.200	0.120	-0.120	4.240	4.230	4.090	4.080	45	45
R5464K**207**AD	4.270	4.100	2.200	0.100	-0.100	4.240	4.150	4.090	4.000	45	45
R5464K**208**AD	4.270	4.100	2.200	0.200	-0.200	4.240	4.230	4.090	4.080	45	45
R5464K**212**DD	4.270	4.100	2.200	0.160	-0.120	4.240	4.050	4.090	3.900	50	50
R5464K**213**AD	4.240	4.100	2.200	0.195	-0.110	4.215	4.165	4.090	4.040	45	40
R5464K**214**AD	4.390	4.190	2.200	0.180	-0.100	4.350	4.250	4.200	4.100	45	40
R5464K**215**AD	4.400	4.300	2.450	0.100	-0.075	4.370	4.270	4.220	4.120	45	40
R5464K**216**AD	4.425	4.325	2.300	0.100	-0.075	4.395	4.295	4.245	4.145	45	40

BLOCK DIAGRAMS

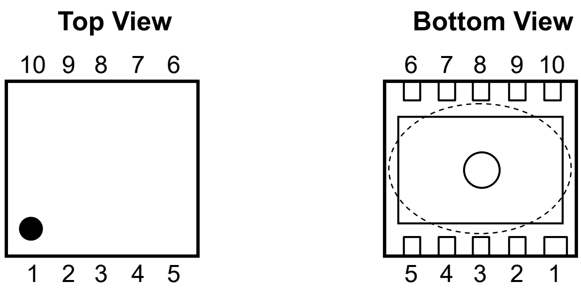


R5464KxxxxD Block Diagram



R5464KxxxxG Block Diagram

PIN DESCRIPTIONS



DFN (PL) 2527-10 Pin Configuration

DFN(PL)2527-10 Pin Description

Pin No.	Symbol	Description
1	VDD	Power supply pin. Substrate level of the IC
2	VSS	GND pin
3	RIN	Termination input pin of an external resistor
4	TIN	Divider resister input pin between an external thermistor and an external resistor
5	VC	Input pin of the center voltage between two-cell
6	COUT	Output pin of over-charge detection, CMOS output
7	V−	Charger negative input pin
8	PS	Over-charge alarm output Pch source pin
9	AOUT	Over-charge alarm output pin. Pch open drain output
10	DOUT	Output pin of over-discharge detection, CMOS output

∗ The tab on the bottom of the package is substrate level (V_{DD}). It is recommended that the tab be connected to the VDD pin on the board, or otherwise be left floating.

ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings

Symbol	Item	Rating	Unit
V_{DD}	VDD Pin Voltage	−0.3 to 12	V
V_C	VC Pin Voltage	V_{SS} −0.3 to V_{DD} +0.3	V
V−	V− Pin Voltage	V_{DD} −30 to V_{DD} +0.3	V
V_{COUT}	COUT Pin Voltage	V_{DD} −30 to V_{DD} +0.3	V
V_{DOUT}	DOUT Pin Voltage	V_{SS} −0.3 to V_{DD} +0.3	V
V_{AOUT}	AOUT Pin Voltage	V_{DD} −30 to V_{DD} +0.3	V
P_D	Power Dissipation(1) (DFN(PL)2527-10, JEDEC STD.51-7 Test Land Pattern)	2800	mW
Tj	Junction Temperature Range	−40 to 125	°C
Tstg	Storage Temperature Range	−55 to 125	°C

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

RECOMMENDED OPERATING CONDITION

Symbol	Item	Rating	Unit
V_{DD1}	Operating Input Voltage	1.5 to 10.0	V
Ta	Operating Temperature Range	−40 to 85	°C

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

(1) Refer to *POWER DISSIPATION* in *SUPPLEMENTSRY ITEMS* for detail information.

ELECTRICAL CHARACTERISTICS

R5464KxxxAD Electrical Characteristics (Ta = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	Note
V_{DD1}	Operating Input Voltage	Voltage between VDD and VSS	1.5		10	V	A
Vnochu	Max. Un-chargeable Voltage of CELL1	Voltage between VDD and VC	0.6	0.8	1.0	V	B
Vnochl	Max. Un-chargeable Voltage of CELL2	Voltage between VC and VSS	0.6	0.8	1.0	V	D
V_{DET1U}	Overcharge Detection Voltage of CELL1	R1 = 330 Ω, Ta = 0°C to 50°C(1)	V_{DET1U} −0.015	V_{DET1U}	V_{DET1U} +0.010	V	B
V_{REL1U}	Overcharge Restoration Voltage of CELL1	R1 = 330 Ω	V_{REL1U} −0.030	V_{REL1U}	V_{REL1U} +0.030	V	B
V_{ALMU}	Overcharge Alarm Detection Voltage of CELL1	R1 = 330 Ω, Ta = 0°C to 45°C(1)	V_{ALMU} −0.015	V_{ALMU}	V_{ALMU} +0.010	V	C
V_{RALU}	Overcharge Alarm Restoration of CELL1	R1 = 330 Ω, Ta = 0°C to 45°C(1)	V_{RALU} −0.030 V_{RALU} −0.030(2)	V_{RALU}	V_{RALU} +0.010 V_{RALU} +0.030(2)	V	C
V_{ALMUH}	Overcharge Alarm Detection Voltage of CELL1 (High Temp.)	R1 = 330 Ω, Ta = 45°C to 60°C(1)	V_{ALMUH} −0.015	V_{ALMUH}	V_{ALMUH} +0.010	V	C
V_{RALUH}	Overcharge Alarm Restoration Voltage of CELL1 (High Temp.)	R1 = 330 Ω, Ta = 45°C to 60°C(1)	V_{RALUH} −0.030 V_{RALUH} −0.030(2)	V_{RALUH}	V_{RALUH} +0.010 V_{RALUH} +0.030(2)	V	C
V_{DET1L}	Overcharge Detection Voltage of CELL2	R2 = 330 Ω, Ta = 0°C to 50°C(1)	V_{DET1L} −0.015	V_{DET1L}	V_{DET1L} +0.010	V	D
V_{REL1L}	Overcharge Restoration Voltage of CELL2	R2 = 330 Ω	V_{REL1L} −0.030	V_{REL1L}	V_{REL1L} +0.030	V	D
V_{ALML}	Overcharge Alarm Detection Voltage of CELL2	R2 = 330 Ω, Ta = 0°C to 45°C(1)	V_{ALML} −0.015	V_{ALML}	V_{ALML} +0.010	V	E
V_{RALL}	Overcharge Alarm Restoration Voltage of CELL2	R2 = 330 Ω, Ta = 0°C to 45°C(1)	V_{RALL} −0.030 V_{RALL} −0.030(2)	V_{RALL}	V_{RALL} +0.010 V_{RALL} +0.030(2)	V	E
V_{ALMLH}	Overcharge Alarm Detection Voltage of CELL2 (High Temp.)	R2 = 330 Ω, Ta = 45°C to 60°C(1)	V_{ALMLH} −0.015	V_{ALMLH}	V_{ALMLH} +0.010	V	E
V_{RALLH}	Overcharge Alarm Restoration Voltage of CELL2 (High Temp.)	R2 = 330 Ω, Ta = 45°C to 60°C(1)	V_{RALLH} −0.030 V_{RALLH} −0.030(2)	V_{RALLH}	V_{RALLH} +0.010 V_{RALLH} +0.030(2)	V	E
T_{ALH1}	Alarm Detection Temp. (High)			45		°C	C
T_{RAH1}	Alarm Restoration Temp. (High)			T_{RAH1}		°C	C
t_{VDET1}	Overcharge Detection Delay Time	$V_{DD}-V_C$ = 3.5 V → 4.5 V, V_C-V_{SS} = 3.5 V	0.7	1.0	1.3	s	B
t_{VREL1}	Overcharge Restoration Delay Time	$V_{DD}-V_C$ = 4.5 V → 3.5 V, V_C-V_{SS} = 3.5 V	11	16	21	ms	B
t_{VALM}	Alarm Detection Delay Time	$V_{DD}-V_C$ = 3.5 V → 4.5 V, V_C-V_{SS} = 3.5 V	4	6	8	ms	C
t_{VRAL}	Alarm Detection Restoration Time	$V_{DD}-V_C$ = 4.5 V → 3.5 V, V_C-V_{SS} = 3.5 V	1.4	1.9	2.4	ms	C

(1) 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 mass production tested.

(2) If there's no alarm restoration hysteresis, the max. restoration voltage is +0.010 V and the min. restoration voltage is –0.030 V. However, if there's a hysteresis, the max. restoration voltage is +0.030 V and the min. restoration voltage is –0.030 V.

R5464KxxxAD Electrical Characteristics (Continued) (Ta = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	Note
V_{DET2U}	Over-discharge Detection Voltage of CELL1	Falling Voltage Detection	V_{DET2U} –0.050	V_{DET2U}	V_{DET2U} +0.050	V	F
V_{DET2L}	Over-discharge Detection Voltage of CELL2	Falling Voltage Detection	V_{DET2L} –0.050	V_{DET2L}	V_{DET2L} +0.050	V	G
V_{REL2U}	Over-discharge Release Voltage of CELL1	Rising Voltage Detection	V_{DET2U} ×0.975	V_{DET2U}	V_{DET2U} ×1.025 +0.045	V	F
V_{REL2L}	Over-discharge Release Voltage of CELL2	Rising Voltage Detection	V_{DET2L} ×0.975	V_{DET2L}	V_{DET2L} ×1.025	V	G
t_{VDET2}	Over-discharge Detection Delay Time	$V_{DD} – V_C$ = 3.5 V → 2.2 V, $V_C – V_{SS}$ = 3.5 V	89	128	167	ms	F
t_{VREL2}	Over-discharge Restoration Delay Time	$V_{DD} – V_C$ = 2.2 V → 3.5 V, $V_C – V_{SS}$ = 3.5 V	0.7	1.2	1.7	ms	F
V_{DET3}	Discharge Overcurrent Detection Voltage	Rising Voltage Detection	V_{DET3} –0.015	V_{DET3}	V_{DET3} +0.015	V	H
t_{VDET3}	Discharge Overcurrent Detection Delay Time	$V_{DD} – V_C$ = 3.5 V, $V_C – V_{SS}$ = 3.5 V, V– = 0 V → 0.5 V	8	12	16	ms	H
t_{VREL3}	Discharge Overcurrent Restoration Delay Time	$V_{DD} – V_C$ = 3.5 V, $V_C – V_{SS}$ = 3.5 V, V– = 3 V → 0 V	0.7	1.2	1.7	ms	H
Vshort	Short-circuit Detection Voltage	$V_{DD} – V_C$ = 3.5 V, $V_C – V_{SS}$ = 3.5 V	0.6	1.0	1.4	V	H
tshort	Short-circuit Detection Delay Time	$V_{DD} – V_C$ = 3.5 V, $V_C – V_{SS}$ = 3.5 V, V– = 0 V → 7 V	230	300	500	µs	H
Rshort	Discharge Overcurrent Restoration Resistance	$V_{DD} – V_C$ = 3.5 V, $V_C – V_{SS}$ = 3.5 V, V– = 1 V	25	40	75	kΩ	H
V_{DET4}	Charge Overcurrent Detection Voltage	Falling Voltage Detection	V_{DET4} –0.020	V_{DET4}	V_{DET4} +0.020	V	I
t_{VDET4}	Charge Overcurrent Detection Delay Time	V_{DD} – VC = 3.5 V, $V_C – V_{SS}$ = 3.5 V, V– = 0 V → –1 V	5	8	11	ms	I
t_{VREL4}	Charge Overcurrent Restoration Delay Time	$V_{DD} – V_C$ = 3.5 V, $V_C – V_{SS}$ = 3.5 V, V– = –1 V → 0 V	0.7	1.2	1.7	ms	I
V_{DS}	Delay Time Shortening Mode	$V_{DD} – V_C$ = 4.4 V, $V_C – V_{SS}$ = 4.4 V	–2.2	–1.6	–1.0	V	I
V_{OL1}	Nch On-voltage of COUT	I_{OL} = 50 µA, $V_{DD} – V_C$ = 4.5 V, $V_C – V_{SS}$ = 4.5 V		0.4	0.5	V	J
V_{OH1}	Pch On-voltage of COUT	I_{OH} = −50 µA, $V_{DD} – V_C$ = 3.9 V, $V_C – V_{SS}$ = 3.9 V	6.8	7.4		V	K
V_{OL2}	Nch On-voltage of DOUT	I_{OL} = 50 µA, $V_{DD} – V_C$ = 2.0 V, $V_C – V_{SS}$ = 2.0 V		0.2	0.5	V	L
V_{OH2}	Pch On-voltage of DOUT	I_{DD} = −50 µA, $V_{DD} – V_C$ = 3.9 V, $V_C – V_{SS}$ = 3.9 V	6.8	7.4		V	M
V_{OH3}	Pch On-voltage of AOUT	I_{DD} = −50 µA, $V_{DD} – V_C$ = 4.5 V, $V_C – V_{SS}$ = 4.5 V	8.0	8.6		V	N
I_{DD}	Supply Current	$V_{DD} – V_C$ = 3.9 V, $V_C – V_{SS}$ = 3.9 V, V– = 0 V		6.0	12.0	µA	P
Istandby	Standby Current	$V_{DD} – V_C$ = 2.0 V, $V_C – V_{SS}$ = 2.0 V			0.1	µA	P

R5464KxxxDD Electrical Characteristics (Ta = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	Note
V_{DD1}	Operating Input Voltage	Voltage between VDD and VSS	1.5		10	V	A
Vnochu	Max. Un-chargeable Voltage of CELL1	Voltage between VDD and VC	0.6	0.8	1.0	V	B
Vnochl	Max. Un-chargeable Voltage of CELL2	Voltage between VC and VSS	0.6	0.8	1.0	V	D
V_{DET1U}	Over-charge Detection Voltage of CELL1	R1 = 330 Ω, Ta = 0°C to 50°C(1)	V_{DET1U} –0.015	V_{DET1U}	V_{DET1U} +0.010	V	B
V_{REL1U}	Over-charge Restoration Voltage of CELL1	R1 = 330 Ω	V_{REL1U} –0.030	V_{REL1U}	V_{REL1U} +0.030	V	B
V_{ALMU}	Over-charge Alarm Detection Voltage of CELL1	R1 = 330 Ω, Ta = 0°C to 45°C(1)	V_{ALMU} –0.015	V_{ALMU}	V_{ALMU} +0.010	V	C
V_{RALU}	Over-charge Alarm Restoration Voltage of CELL1	R1 = 330 Ω, Ta = 0°C to 45V(1)	V_{RALU} –0.030 V_{RALU} –0.030(2)	V_{RALU}	V_{RALU} +0.010 V_{RALU} +0.030(2)	V	C
V_{ALMUH}	Over-charge Alarm Detection Voltage of CELL1 (High Temp.)	R1 = 330 Ω, Ta = 45°C to 60°C(1)	V_{ALMUH} –0.015	V_{ALMUH}	V_{ALMUH} +0.010	V	C
V_{RALUH}	Over-charge Alarm Restoration Voltage of CELL1 (High Temp.)	R1 = 330 Ω, Ta = 45°C to 60°C(1)	V_{RALUH} –0.030 V_{RALUH} –0.030(2)	V_{RALUH}	V_{RALUH} +0.010 V_{RALUH} +0.030(2)	V	C
V_{DET1L}	Over-charge Detection Voltage of CELL2	R2 = 330 Ω, Ta = 0°C to 50°C(1)	V_{DET1L} –0.015	V_{DET1L}	V_{DET1L} +0.010	V	D
V_{REL1L}	Over-charge Restoration Voltage of CELL2	R2 = 330 Ω	V_{REL1L} –0.030	V_{REL1L}	V_{REL1L} +0.030	V	D
V_{ALML}	Over-charge Alarm Detection Voltage of CELL2	R2 = 330 Ω, Ta = 0°C to 45°C(1)	V_{ALML} –0.015	V_{ALML}	V_{ALML} +0.010	V	E
V_{RALL}	Over-charge Alarm Restoration Voltage of CELL2	R2 = 330 Ω, Ta = 0°C to 45°C(1)	V_{RALL} –0.030 V_{RALL} –0.030(2)	V_{RALL}	V_{RALL} +0.010 V_{RALL} +0.030(2)	V	E
V_{ALMLH}	Over-charge Alarm Detection Voltage of CELL2 (High Temp.)	R2 = 330 Ω, Ta = 45°C to 60°C(1)	V_{ALMLH} –0.015	V_{ALMLH}	V_{ALMLH} +0.010	V	E
V_{RALLH}	Over-charge Alarm Restoration Voltage of CELL2 (High Temp.)	R2 = 330 Ω, Ta = 45°C to 60°C(1)	V_{RALLH} –0.030 V_{RALLH} –0.030(2)	V_{RALLH}	V_{RALLH} +0.010 V_{RALLH} +0.030(2)	V	E
T_{ALH1}	Alarm Detection Temp. (High)			45		°C	C
T_{RAH1}	Alarm Restoration Temp. (High)			T_{RAH1}		°C	C
t_{VDET1}	Over-charge Detection Delay Time	$V_{DD} – V_C$ = 3.5 V → 4.5 V, $V_C – V_{SS}$ = 3.5 V	0.7	1.0	1.3	s	B
t_{VREL1}	Over-charge Restoration Delay Time	$V_{DD} – V_C$ = 4.5 V → 3.5 V, $V_C – V_{SS}$ = 3.5 V	11	16	21	ms	B
t_{VALM}	Alarm Detection Delay Time	$V_{DD} – V_C$ = 3.5 V → 4.5 V, $V_C – V_{SS}$ = 3.5 V	25	36	47	ms	C
t_{VRAL}	Alarm Detection Restoration Time	$V_{DD} – V_C$ = 4.5 V → 3.5 V, $V_C – V_{SS}$ = 3.5 V	1.4	1.9	2.4	ms	C

(1) 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 mass production tested.
(2) If there's no alarm restoration hysteresis, the max. restoration voltage is +0.010 V and the min. restoration voltage is –0.030 V. However, if there's a hysteresis, the max. restoration voltage is +0.030 V and the min. restoration voltage is –0.030 V.

R5464KxxxDD Electrical Characteristics (Continued) (Ta = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	Note
V_{DET2U}	Over-discharge Detection Voltage of CELL1	Falling Voltage Detection	V_{DET2U} –0.050	V_{DET2U}	V_{DET2U} +0.050	V	F
V_{DET2L}	Over-discharge Detection Voltage of CELL2	Falling Voltage Detection	V_{DET2L} –0.050	V_{DET2L}	V_{DET2L} +0.050	V	G
V_{REL2U}	Over-discharge Release Voltage of CELL1	Rising Voltage Detection	V_{DET2U} ×0.975	V_{DET2U}	V_{DET2U} ×1.025 +0.045	V	F
V_{REL2L}	Over-discharge Release Voltage of CELL2	Rising Voltage Detection	V_{DET2L} ×0.975	V_{DET2L}	V_{DET2L} ×1.025	V	G
t_{VDET2}	Over-discharge Detection Delay Time	$V_{DD} - V_C$ = 3.5 V → 2.2 V, $V_C - V_{SS}$ = 3.5 V	89	128	167	ms	F
t_{VREL2}	Over-discharge Restoration Delay Time	$V_{DD} - V_C$ = 2.2 V → 3.5 V, $V_C - V_{SS}$ = 3.5 V	0.7	1.2	1.7	ms	F
V_{DET3}	Discharge Overcurrent Detection Voltage	Rising Voltage Detection	V_{DET3} −0.015	V_{DET3}	V_{DET3} +0.015	V	H
t_{VDET3}	Discharge Overcurrent Detection Delay Time	$V_{DD} - V_C$ = 3.5 V, $V_C - V_{SS}$ = 3.5 V, V– = 0 V → 0.5 V	8	12	16	ms	H
t_{VREL3}	Discharge Overcurrent Restoration Delay Time	$V_{DD} - V_C$ = 3.5 V, $V_C - V_{SS}$ = 3.5 V, V– = 3 V → 0 V	0.7	1.2	1.7	ms	H
Vshort	Short-circuit Detection Voltage	$V_{DD} - V_C$ = 3.5 V, $V_C - V_{SS}$ = 3.5 V	0.6	1.0	1.4	V	H
tshort	Short-circuit Detection Delay Time	$V_{DD} - V_C$ = 3.5 V, $V_C - V_{SS}$ = 3.5 V, V– = 0 V → 7 V	230	300	500	μs	H
Rshort	Discharge Overcurrent Restoration Resistance	$V_{DD} - V_C$ = 3.5 V, $V_C - V_{SS}$ = 3.5 V, V– = 1 V	25	40	75	kΩ	H
V_{DET4}	Charge Overcurrent Detection Voltage	Falling Voltage Detection	V_{DET4} −0.020	V_{DET4}	V_{DET4} +0.020	V	I
t_{VDET4}	Charge Overcurrent Detection Delay Time	$V_{DD} - V_C$ = 3.5 V, $V_C - V_{SS}$ = 3.5 V, V– = 0 V → –1 V	5	8	11	ms	I
t_{VREL4}	Charge Overcurrent Restoration Delay Time	$V_{DD} - V_C$ = 3.5 V, $V_C - V_{SS}$ = 3.5 V, V– = –1 V → 0 V	0.7	1.2	1.7	ms	I
V_{DS}	Delay Time Shortening Mode	$V_{DD} - V_C$ = 4.4 V, $V_C - V_{SS}$ = 4.4 V	−2.2	−1.6	−1.0	V	I
V_{OL1}	Nch On-voltage of COUT	I_{OL} = 50 μA, $V_{DD} - V_C$ = 4.5 V, $V_C - V_{SS}$ = 4.5 V		0.4	0.5	V	J
V_{OH1}	Pch On-voltage of COUT	I_{OH} = –50 μA, $V_{DD} - V_C$ = 3.9 V, $V_C - V_{SS}$ = 3.9 V	6.8	7.4		V	K
V_{OL2}	Nch On-voltage of DOUT	I_{OL} = 50 μA, $V_{DD} - V_C$ = 2.0 V, $V_C - V_{SS}$ = 2.0 V		0.2	0.5	V	L
V_{OH2}	Pch On-voltage of DOUT	I_{DD} = –50 μA, $V_{DD} - V_C$ = 3.9 V, $V_C - V_{SS}$ = 3.9 V	6.8	7.4		V	M
V_{OH3}	Pch On-voltage of AOUT	I_{DD} = −50 μA, $V_{DD} - V_C$ = 4.5 V, $V_C - V_{SS}$ = 4.5 V	8.0	8.6		V	N
I_{DD}	Supply Current	$V_{DD} - V_C$ = 3.9 V, $V_C - V_{SS}$ = 3.9 V, V– = 0 V		6.0	12.0	μA	P
Istandby	Standby Current	$V_{DD} - V_C$ = 2.0 V, $V_C - V_{SS}$ = 2.0 V			0.1	μA	P

R5464KxxxCG Electrical Characteristics (Ta = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	Note
V_{DD1}	Operating Input Voltage	Voltage between VDD and VSS	1.5		10	V	A
Vst	Min. Operating Voltage of 0-V Battery Charge	Voltage between VDD and V–, $V_{DD} - V_{SS}$ = 0 V			1.8	V	A
V_{DET1U}	Over-charge Detection Voltage of CELL1	R1 = 330 Ω, Ta = 0°C to 50°C[1]	V_{DET1U} –0.015	V_{DET1U}	V_{DET1U} +0.010	V	B
V_{REL1U}	Over-charge Restoration Voltage of CELL1	R1 = 330 Ω	V_{REL1U} –0.030	V_{REL1U}	V_{REL1U} +0.030	V	B
V_{ALMU}	Over-charge Alarm Detection Voltage of CELL1	R1 = 330 Ω, Ta = 0°C to 45°C[1]	V_{ALMU} –0.015	V_{ALMU}	V_{ALMU} +0.010	V	C
V_{RALU}	Over-charge Alarm Restoration Voltage of CELL1	R1 = 330 Ω, Ta = 0°C to 45°C[1]	V_{RALU} –0.030 V_{RALU} –0.030[2]	V_{RALU}	V_{RALU} +0.010 V_{RALU} +0.030[2]	V	C
V_{ALMUH}	Over-charge Alarm Detection Voltage of CELL1 (High Temp.)	R1 = 330 Ω, Ta = 45°C to 60°C[1]	V_{ALMUH} –0.015	V_{ALMUH}	V_{ALMUH} +0.010	V	C
V_{RALUH}	Over-charge Alarm Restoration Voltage of CELL1 (High Temp.)	R1 = 330 Ω, Ta = 45°C to 60°C[1]	V_{RALUH} –0.030 V_{RALUH} –0.030[2]	V_{RALUH}	V_{RALUH} +0.010 V_{RALUH} +0.030[2]	V	C
V_{DET1L}	Over-charge Detection Voltage of CELL2	R2 = 330 Ω, Ta = 0°C to 50°C[1]	V_{DET1L} –0.015	V_{DET1L}	V_{DET1L} +0.010	V	D
V_{REL1L}	Over-charge Restoration Voltage of CELL2	R2 = 330 Ω	V_{REL1L} –0.030	V_{REL1L}	V_{REL1L} +0.030	V	D
V_{ALML}	Over-charge Alarm Detection Voltage of CELL2	R2 = 330 Ω, Ta = 0°C to 45°C[1]	V_{ALML} –0.015	V_{ALML}	V_{ALML} +0.010	V	E
V_{RALL}	Over-charge Alarm Restoration Voltage of CELL2	R2 = 330 Ω, Ta = 0°C to 45°C[1]	V_{RALL} –0.030 V_{RALL} –0.030[2]	V_{RALL}	V_{RALL} +0.010 V_{RALL} +0.030[2]	V	E
V_{ALMLH}	Over-charge Alarm Detection Voltage of CELL2 (High Temp.)	R2 = 330 Ω, Ta = 45°C to 60°C[1]	V_{ALMLH} –0.015	V_{ALMLH}	V_{ALMLH} +0.010	V	E
V_{RALLH}	Over-charge Alarm Restoration Voltage of CELL2 (High temp.)	R2 = 330 Ω, Ta = 45°C to 60°C[1]	V_{RALLH} –0.030 V_{RALLH} –0.030[2]	V_{RALLH}	V_{RALLH} +0.010 V_{RALLH} +0.030[2]	V	E
T_{ALH1}	Alarm Detection Temp. (High)			45		°C	C
T_{RAH1}	Alarm Restoration Temp. (High)			T_{RAH1}		°C	C
t_{VDET1}	Over-charge Detection Delay Time	$V_{DD} - V_C$ = 3.5 V → 4.5 V, $V_C - V_{SS}$ = 3.5 V	0.7	1.0	1.3	s	B
t_{VREL1}	Over-charge Restoration Delay Time	$V_{DD} - V_C$ = 4.5 V → 3.5 V, $V_C - V_{SS}$ = 3.5 V	11	16	21	ms	B
t_{VALM}	Alarm Detection Delay Time	$V_{DD} - V_C$ = 3.5 V → 4.5 V, $V_C - V_{SS}$ = 3.5 V	4	6	8	ms	C
t_{VRAL}	Alarm Detection Restoration Time	$V_{DD} - V_C$ = 4.5 V → 3.5 V, $V_C - V_{SS}$ = 3.5 V	1.4	1.9	2.4	ms	C

[1] 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 mass production tested.

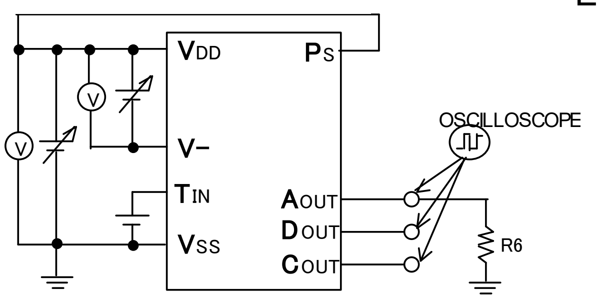
[2] If there's no alarm restoration hysteresis, the max. restoration voltage is +0.010 V and the min. restoration voltage is –0.030 V. However, if there's a hysteresis, the max. restoration voltage is +0.030 V and the min. restoration voltage is –0.030 V.

R5464KxxxCG Electrical Characteristics (Continued) (Ta = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	Note
V_{DET2U}	Over-discharge Detection Voltage of CELL1	Falling Voltage Detection	V_{DET2U} −0.050	V_{DET2U}	V_{DET2U} +0.050	V	F
V_{DET2L}	Over-discharge Detection Voltage of CELL2	Falling Voltage Detection	V_{DET2L} −0.050	V_{DET2L}	V_{DET2L} +0.050	V	G
V_{REL2U}	Over-discharge Release Voltage of CELL1	Rising Voltage Detection	V_{DET2U} ×0.975	V_{DET2U}	V_{DET2U} ×1.025 +0.045	V	F
V_{REL2L}	Over-discharge Release Voltage of CELL2	Rising Voltage Detection	V_{DET2L} ×0.975	V_{DET2L}	V_{DET2L} ×1.025	V	G
t_{VDET2}	Over-discharge Detection Delay Time	$V_{DD} - V_C$ = 3.5 V → 2.2 V, $V_C - V_{SS}$ = 3.5 V	89	128	167	ms	F
t_{VREL2}	Over-discharge Restoration Delay Time	$V_{DD} - V_C$ = 2.2 V → 3.5 V, $V_C - V_{SS}$ = 3.5 V	0.7	1.2	1.7	ms	F
V_{DET3}	Discharge Overcurrent Detection Voltage	Rising Voltage Detection	V_{DET3} −0.015	V_{DET3}	V_{DET3} +0.015	V	H
t_{VDET3}	Discharge Overcurrent Detection Delay Time	$V_{DD} - V_C$ = 3.5 V, $V_C - V_{SS}$ = 3.5 V, $V-$ = 0 V → 0.5 V	11	16	21	ms	H
t_{VREL3}	Discharge Overcurrent Restoration Delay Time	$V_{DD} - V_C$ = 3.5 V, $V_C - V_{SS}$ = 3.5 V, $V-$ = 3 V → 0 V	0.7	1.2	1.7	ms	H
Vshort	Short-circuit Detection Voltage	$V_{DD} - V_C$ = 3.5 V, $V_C - V_{SS}$ = 3.5 V	0.6	1.0	1.4	V	H
tshort	Short-circuit Detection Delay Time	$V_{DD} - V_C$ = 3.5 V, $V_C - V_{SS}$ = 3.5 V, $V-$ = 0 V → 7 V	230	300	500	μs	H
Rshort	Discharge Overcurrent Restoration Resistance	$V_{DD} - V_C$ = 3.5 V, $V_C - V_{SS}$ = 3.5 V, $V-$ = 1 V	25	40	75	kΩ	H
V_{DET4}	Charge Overcurrent Detection Voltage	Falling Voltage Detection	V_{DET4} −0.020	V_{DET4}	V_{DET4} +0.020	V	I
t_{VDET4}	Charge Overcurrent Detection Delay Time	$V_{DD} - V_C$ = 3.5 V, $V_C - V_{SS}$ = 3.5 V, $V-$ = 0 V → −1 V	5	8	11	ms	I
t_{VREL4}	Charge Overcurrent Restoration Delay Time	$V_{DD} - V_C$ = 3.5 V, $V_C - V_{SS}$ = 3.5 V, $V-$ = −1 V → 0 V	0.7	1.2	1.7	ms	I
V_{DS}	Delay Time Shortening Mode Voltage	$V_{DD} - V_C$ = 4.4 V, $V_C - V_{SS}$ = 4.4 V	−2.2	−1.6	−1.0	V	I
V_{OL1}	Nch On-voltage of COUT	I_{OL} = 50 μA, $V_{DD} - V_C$ = 4.5 V, $V_C - V_{SS}$ = 4.5 V		0.4	0.5	V	J
V_{OH1}	Pch On-voltage of COUT	I_{OH} = −50 μA, $V_{DD} - V_C$ = 3.9 V, $V_C - V_{SS}$ = 3.9 V	6.8	7.4		V	K
V_{OL2}	Nch On-voltage of DOUT	I_{OL} = 50 μA, $V_{DD} - V_C$ = 2.0 V, $V_C - V_{SS}$ = 2.0 V		0.2	0.5	V	L
V_{OH2}	Pch On-voltage of DOUT	I_{DD} = −50 μA, $V_{DD} - V_C$ = 3.9 V, $V_C - V_{SS}$ = 3.9 V	6.8	7.4		V	M
V_{OH3}	Pch On-voltage of AOUT	I_{DD} = −50 μA, $V_{DD} - V_C$ = 3.9 V, $V_C - V_{SS}$ = 3.9 V	6.8	7.4		V	N
R_{AOUT}	AOUT Pin Internal Resistance		380	500	620	kΩ	O
I_{DD}	Supply Current	$V_{DD} - V_C$ = 3.9 V, $V_C - V_{SS}$ = 3.9 V, $V-$ = 0 V		5.0	10.0	μA	P
Istandby	Standby Current	$V_{DD} - V_C$ = 2.0 V, $V_C - V_{SS}$ = 2.0 V			0.1	μA	P

Test Circuits

A[1]



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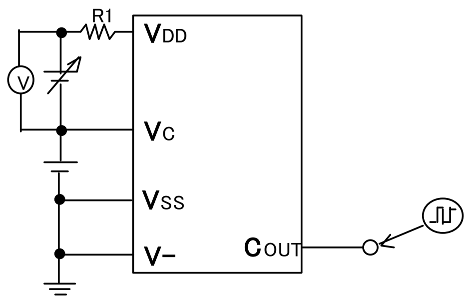

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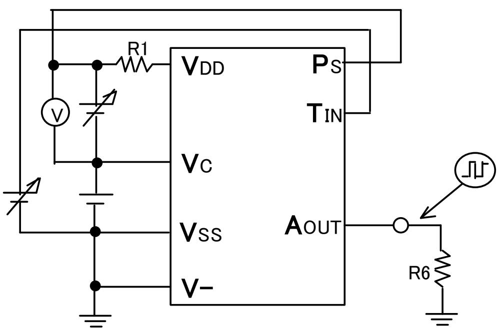

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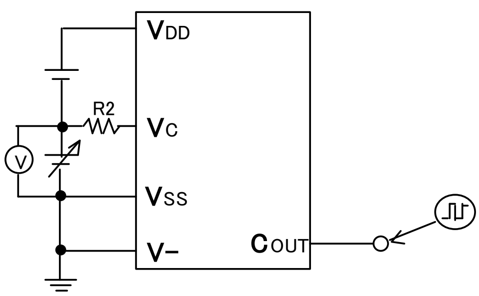

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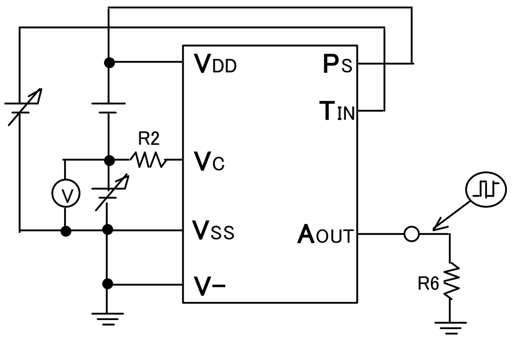

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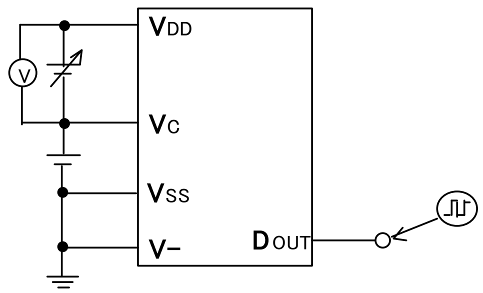

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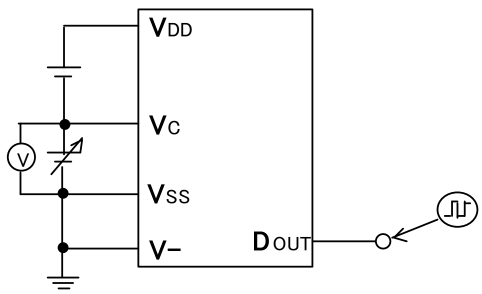

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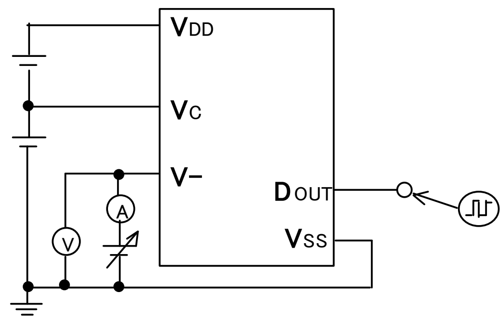

[1] The typical performance characteristics (Part 1) are measured using the following test circuits.

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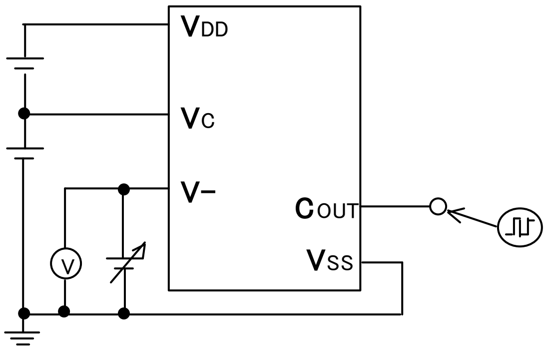
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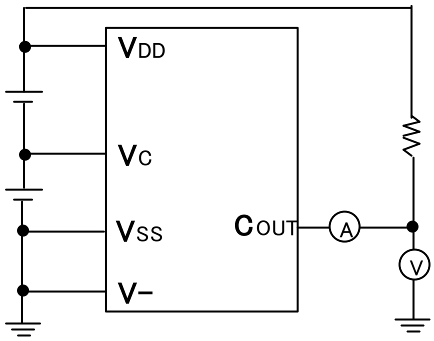
VC
V−
COUT
VSS
V

J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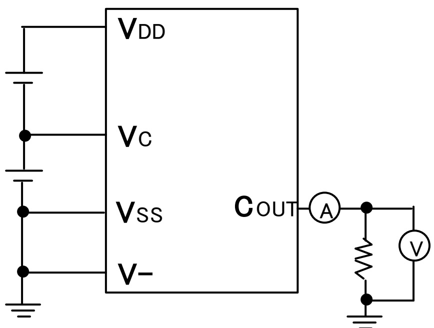
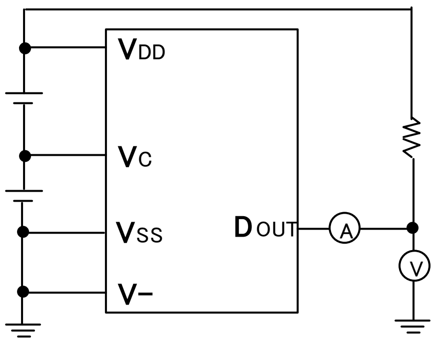
VC
VSS
COUT
V−
A
V

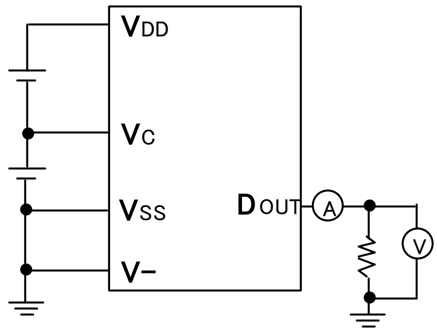
K


VDD
VC
VSS
COUT
V−
A
V

L


VDD
VC
VSS
DOUT
V−
A
V

M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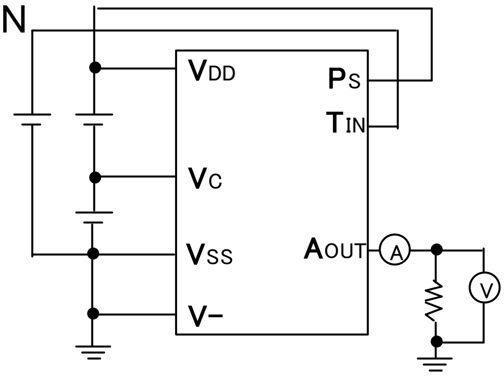
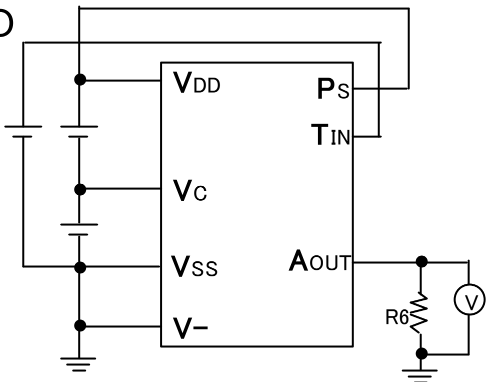
VC
VSS
DOUT
V−
A
V

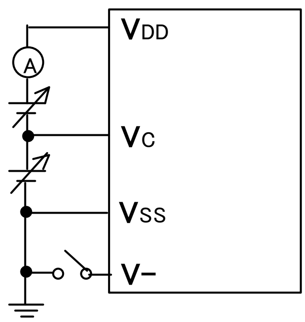
N


VDD
PS
TIN
VC
VSS
AOUT
V−
A
V

O


VDD
PS
TIN
VC
VSS
AOUT
V−
R6
V

P


VDD
A
VC
VSS
V−

OPERATION

1. VD1/ Over-charge Detector

The V_{DET1x} monitors the voltage between VDD pin and VC pin (Cell1) and the voltage between VC pin and VSS pin (Cell2), if either voltage becomes equal or more than the over-charge detector threshold (Typ. 4.240 V), the over-charge is detected, and an external charge control Nch MOSFET turns off with COUT pin being at "L" level.
To reset the over-charge and make the COUT pin level being "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 the over-charge released voltage (Typ. 4.100 V), or when the both Cell1 and Cell2 are lower than the over-charge detector threshold, by connecting a kind of load to VDD after disconnecting a charger from the battery pack. Then, the output voltage of COUT pin becomes "H", and it makes an external Nch MOSFET turn on, and charge cycle is available.
Further, in case that the voltage level of Cell1 and Cell2 is equal or higher than the over-charge detector threshold, when a charger is removed and some load is connected, COUT outputs “L”, however, load current can flow through the parasitic diode of the external charge control Nch MOSFET. After that, when the voltage level of Cell1 and Cell2 becomes lower than the over-charge detector threshold, COUT becomes “H”.
Internal fixed output delay time (Typ. 1.0 s) for over-charge detection and released delay time (Typ. 16 ms) exist. Even when the voltage of Cell1 or Cell2 pin level becomes equal or higher level than V_{DET} 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 voltage level of Cell1 and Cell2 is 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 (Typ. 16 ms) of release from over-charge, over-charge state is not released.
A level shifter incorporated in a buffer driver for the COUT pin makes the "L" level of COUT pin to the V− pin voltage and the "H" level of COUT pin is set to V_{DD} voltage with CMOS buffer.

2. VD2/ Over-discharge Detector

The V_{DET2x} monitors the voltage between VDD pin and VC pin (Cell1) and the voltage between VC pin and VSS pin (Cell2). When the either voltage becomes equal or less than the over-discharge detector threshold (Typ. 2.20 V), the over-discharge is detected and discharge stops by the external discharge control Nch MOSFET turning off with the DOUT 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 over-discharge detector threshold, DOUT becomes “H” and the external MOSFET turns on and discharge will be possible. When a charger is connected, when the Cell1 and Cell2 voltages are more than the over-discharge detector threshold, the over-discharge is released and the voltage of the DOUT 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 (Vnochg),

even if a charger is connected to the battery pack, COUT pin is stacked with "L" and the system is not allowable for charge.

The output delay time for over-discharge detect is fixed internally (Typ. 128 ms). Even if the voltage of Cell1 or Cell2 is down to equal or lower than the over-discharge detector threshold, if the voltage of Cell1 or 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 fixed internally (Typ. 1.2 ms).

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.

(Max. 0.1 μA at $V_{DD}-V_{C} = V_{C} - V_{SS} = 2.0$ V)

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

3. VD3/ Discharge Overcurrent Detector, Short Circuit Protector

When the charge and discharge is acceptable, these detectors monitor the V- pin voltage.

If the V− pin voltage is up to a value equal or more than the discharge overcurrent detector threshold (Typ. 0.195 V) and lower than the short protection voltage Vshort (Typ. 1.0 V) the discharge overcurrent is detected. If the V− pin voltage becomes further higher than Vshort, the short circuit protector is enabled. This leads the external discharge control Nch MOSFET turning off with the DOUT pin being at "L" level to prevent from flowing the large current into the circuit.

An output delay time for the discharge overcurrent detector is internally fixed (Typ. 12 ms).

A quick recovery of V− pin level from a value between Vshort and V_{DET3} within the delay time keeps the discharge control FET staying "H" state. Output delay time for the release from discharge overcurrent detection is also fixed internally (Typ. 1.2 ms).

When the short circuit protector is enabled, the DOUT pin would be "L" and the delay time is also set (Typ. 300 μs).

The V− pin has a built-in pull-down resistor to the VSS pin, that is, the resistance (Typ. 40 kΩ) to release from discharge overcurrent or short circuit.

After an discharge overcurrent or short circuit protection is detected, removing a cause of discharge overcurrent or external short circuit makes an external discharge control FET an "ON" state automatically with the V− pin level being down to the V_{SS} level through the built-in pulled down resistor. (When the V− pin voltage becomes equal or less than discharge overcurrent threshold, the detector is released.) The reset resistor of discharge overcurrent is off when the charge and discharge is acceptable, or normal state. Only when detecting discharge overcurrent or short circuit, the resistor is on.

Output delay time of discharge overcurrent is set shorter than the delay time for over-discharge detector. Therefore, even if the voltage between VDD pin and VC pin (Cell1) or the voltage between VC pin and VSS pin (Cell2) becomes lower than V_{DET2} at the same time as the discharge overcurrent is detected, the R5464K is at discharge overcurrent detection mode. By disconnecting a load, V_{DET3} is automatically released from discharge overcurrent.

4. VD4/ Charge Overcurrent Detector

When the charge and discharge are acceptable, V_{DET4} senses the 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 charge overcurrent detector threshold (Typ. −0.11 V). Then, the output of C_{OUT} becomes "L", and prevents from flowing excess current in the circuit by turning off the external Nch MOSFET. Output delay of charge overcurrent is internally fixed. (Typ. 8 ms) Even the voltage level of V− pin becomes equal or lower than the charge overcurrent detector threshold, the voltage is higher than the V_{DET4} threshold within the delay time, the charge overcurrent is not detected. Output delay for the release from charge overcurrent is also set. (Typ. 1.2 ms)
V_{DET4} can be released with disconnecting a charger and connecting a load.

5. DS (Delay Shortening) function

Output delay time of over-charge and over-discharge can be made shorter than those setting values by forcing equal or lower than the test shortening mode voltage (Typ. −1.6 V) to V− pin.

6. Alarm Detector Circuit

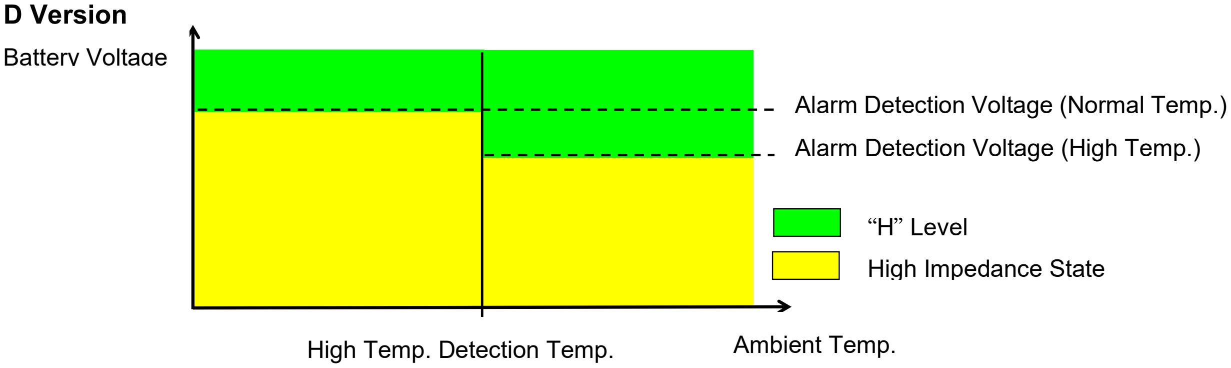
When the detected temperature by an external thermistor is less than 45°C, the alarm detector monitors the voltage between VDD pin and VC pin (Cell1) and the voltage between VC pin and VSS pin (Cell2), if either of them becomes over-charge alarm detector threshold (Typ. 4.215 V), then state becomes alarm, and the AOUT pin outputs from high impedance at normal to "H".
After detecting the over-charge alarm, if the detected temperature of an external thermistor is less than 45°C, when both voltages of cell1 and cell2 become equal or less than the released voltage from over-charge alarm (Typ. 4.165 V), the alarm state is released and the output of AOUT pin changes from "H" state to high impedance.
When the detected temperature by an external thermistor is equal or more than 45°C, while the battery is charged, the voltage between VDD pin and VC pin (Cell1) and the voltage between VC pin and VSS pin (Cell2) are monitored, and either of them becomes equal or more than the over-charge alarm detector threshold at high temperature (Typ. 4.090 V), the alarm state is acknowledged, the output of AOUT pin changes from high impedance at normal state to "H".
After detecting over-charge alarm, if the detected temperature by an external thermistor is equal or more than 45°C, when both voltages of cell1 and cell2 become equal or less than the released voltage from over-charge alarm at high temperature (Typ. 4.040 V), then the alarm state is released and the output of AOUT pin changes from the "H" to high impedance.
The output delay time for the over-charge alarm detect and the release from over-charge alarm exists respectively. The delay time for the over-charge alarm detect is typically 6 ms, and the released output delay time from over-charge alarm is typically 1.9 ms. Even if either of the voltage of cell1 or cell2 becomes equal or more than the over-charge alarm detector threshold, if the voltage recovers within the delay time for over-charge alarm detector, over-charge alarm is not detected. After detecting over-charge alarm, even if both voltages of cell1 and cell2 are less than the over-charge alarm detector, the charger is disconnected and

connect a load, if the state recovers within the output delay time for release from alarm detector, the over-charge alarm state is not released.

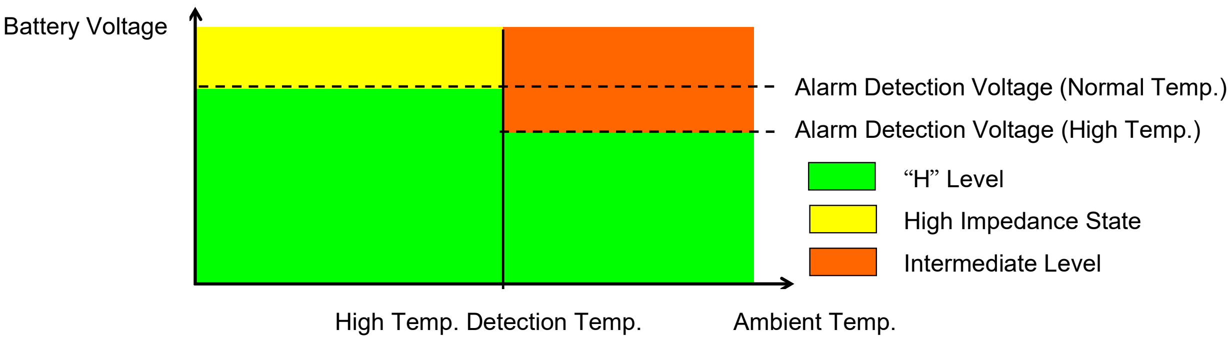
The alarm detector circuits, VD1, VD2, VD3, and VD4 operate individually. When the IC is into standby mode, the alarm detectors also stop.

The output type of AOUT pin is Pch open-drain type, and the source is connected to VDD.

D Version

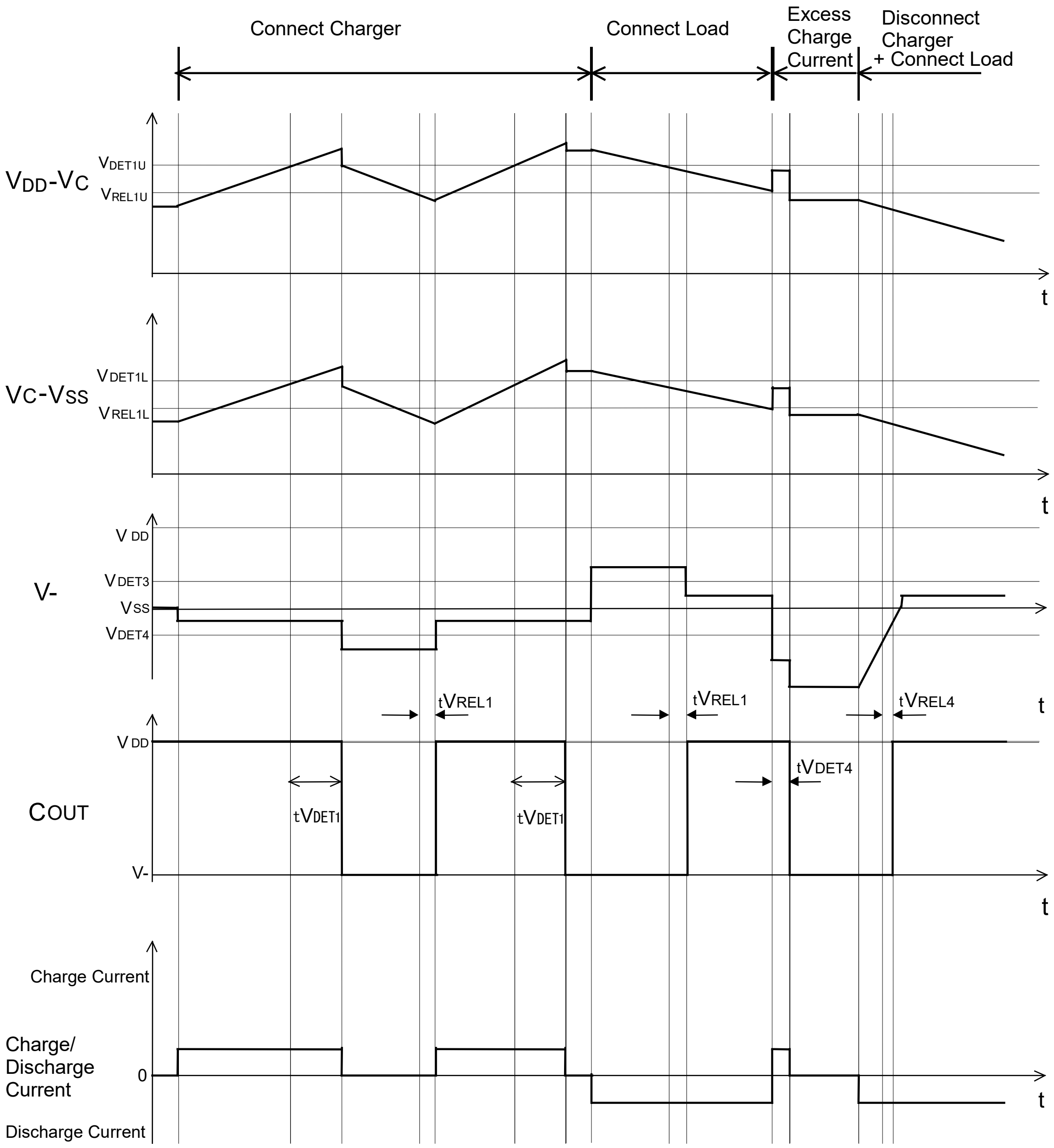


G Version

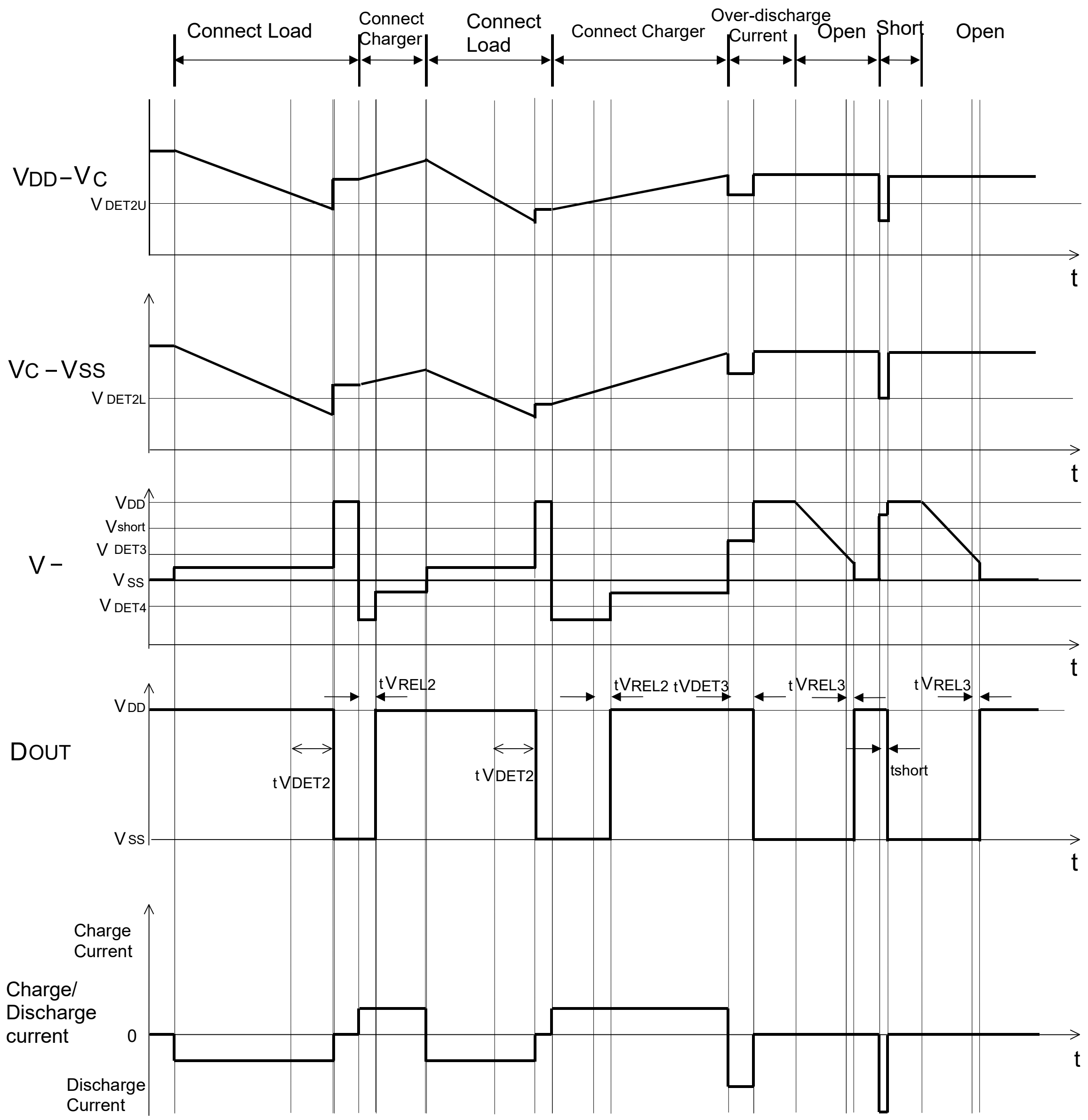


Timing Chart

1. Charge Operation and Charge Overcurrent Operation

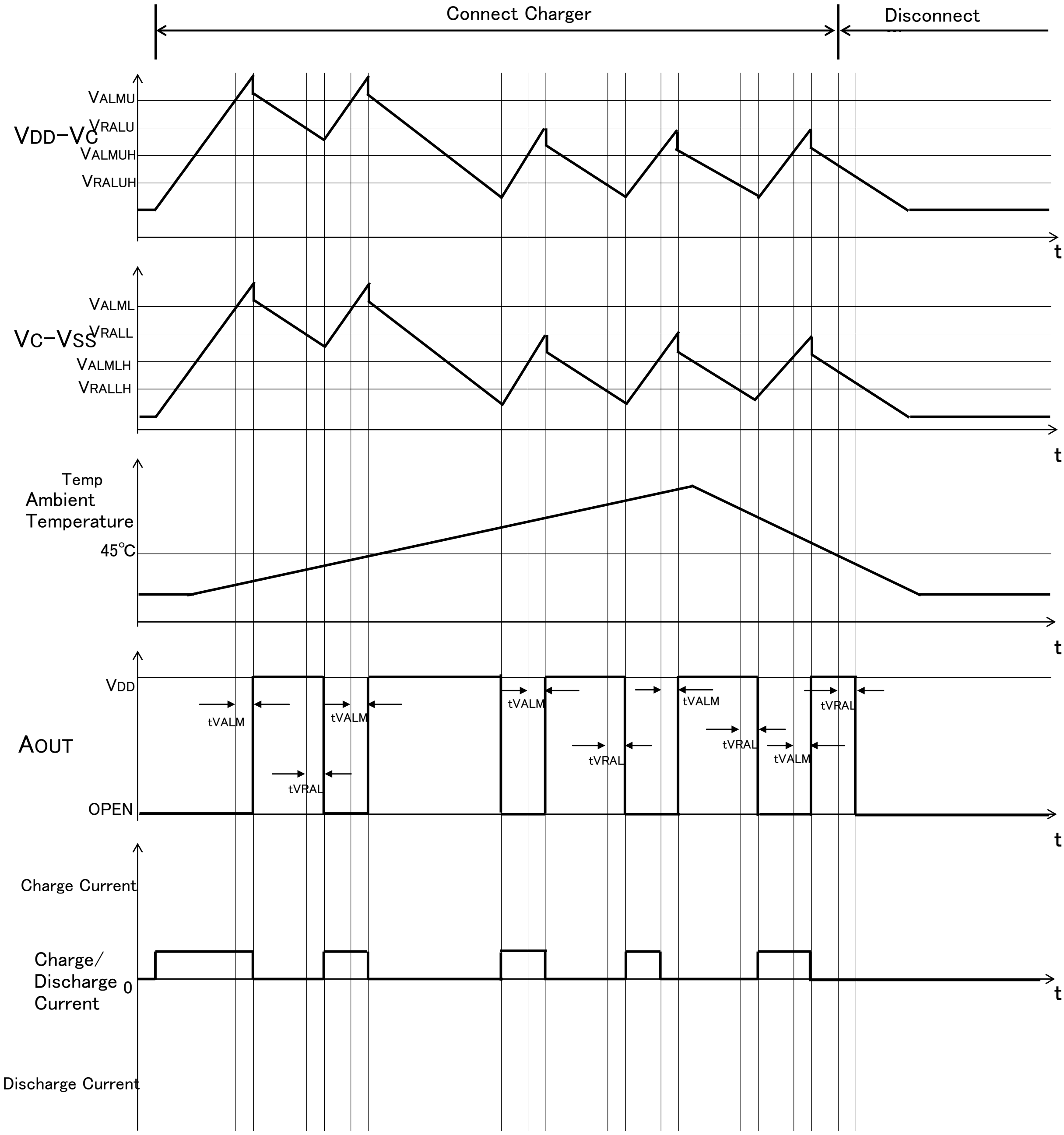


2. Overdischarge Operation, Discharge Overcurrent Operation and Short-circuit Operation

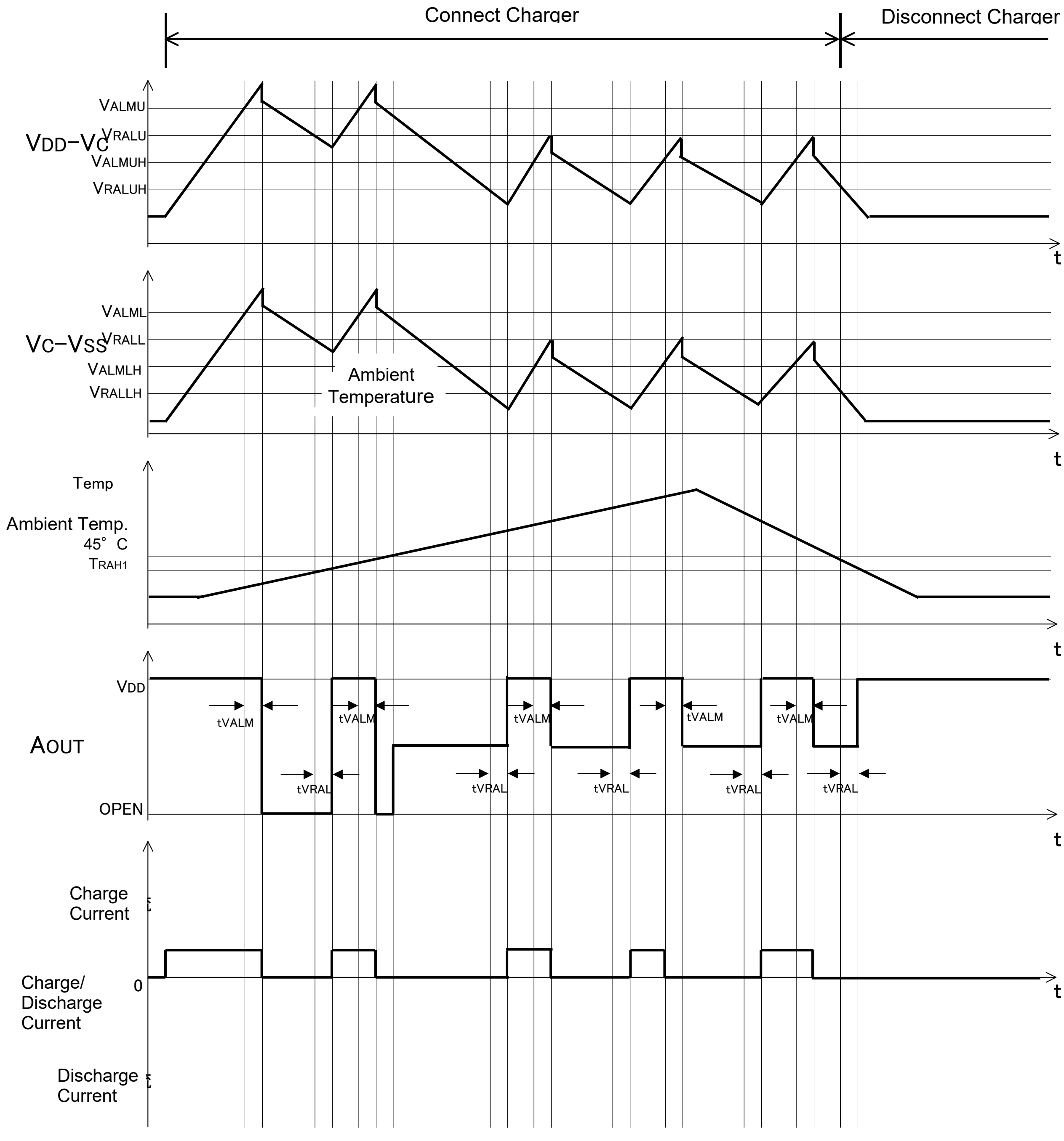


3. Overcharge Alarm Operation

AD/ DD Version

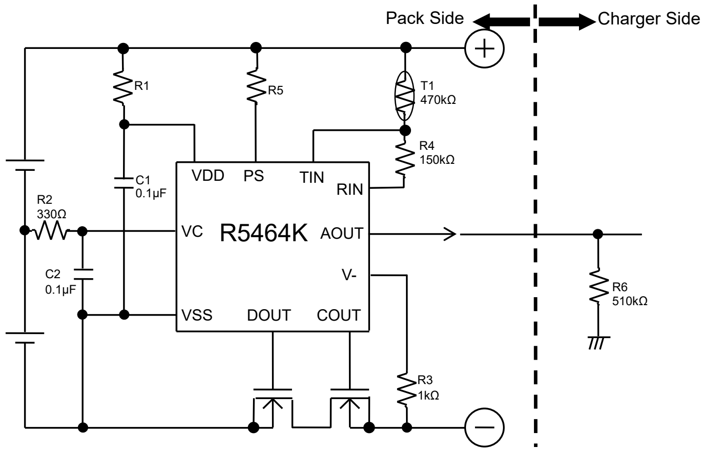


CG Version


Connect Charger
Disconnect Charger
VALMU
VRALU
VDD−VC
VALMUH
VRALUH
t
VALML
VRALL
VC−VSS
VALMLH
VRALLH
Ambient
Temperature
t
Temp
Ambient Temp.
45° C
TRAH1
t
VDD
AOUT
OPEN
tVALM
tVRAL
t
Charge
Current
Charge/
Discharge
Current
0
Discharge
Current
t

APPLICATION INFORMATION

Typical Application Circuit



Typical Application Circuit

Technical Notes on Selection Components

- R1, R2, C1 and C2 stabilize a supply voltage to the R5464xxxxxx. A recommended R1, R2 value is less than 1 kΩ. A larger value of R1 and R2 makes the detection voltage shift higher because of some conduction current in the R5464xxxxxx. To stabilize the operation, the value of C1 and C2 should be equal or more than 0.01 µF.

- 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 R5464xxxxxx, to the battery pack. Small value of R1 and R3 may cause over-power consumption rating of power dissipation of the R5464xxxxx. Thus, the total value of 'R1+R3' should be equal or more than 1 kΩ. If a large value of R3 is set, after detecting overdischarge, the release by connecting a charger may not be possible. Therefore, recommendation value of R3 is equal or less than 3 kΩ.

- The position of a thermistor, T1 depends on the correlation of cell voltage. Therefore, confirm the correlation fully, and decide the position of a thermistor, and setting temperature detect.

- The tolerance of T1 and R4 effects on the tolerance of the temperature detector, therefore, consider the tolerance of these external components.

- 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.

- Overvoltage and the over current beyond the absolute maximum rating should not be forced to the protection IC and external components.

TYPICAL PERFORMANCE CHARACTERISTICS

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

Part 1:

Figure 1. 0-V Battery Charge Min. Operating Voltage vs. Ambient Temp.

R5464x102CG

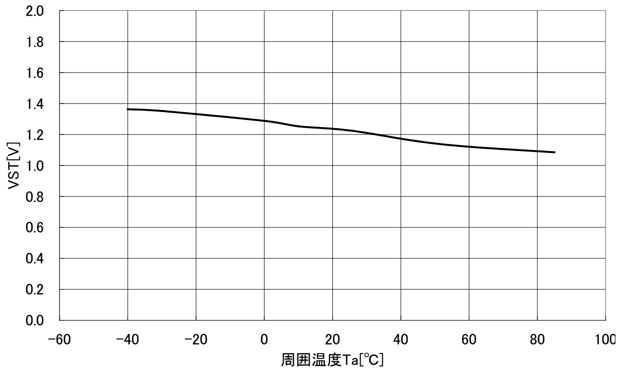


Figure 2. Max. Un-chargeable Voltage (CELL1) vs. Ambient Temp.

R5464x205AD

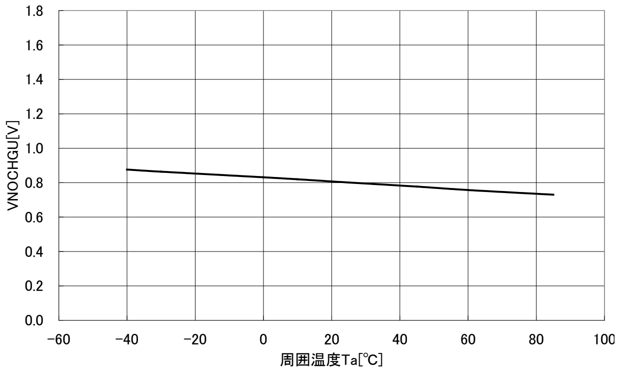


Figure 3. Max. Un-chargeable Voltage (CELL2) vs. Ambient Temp.

R5464x205AD

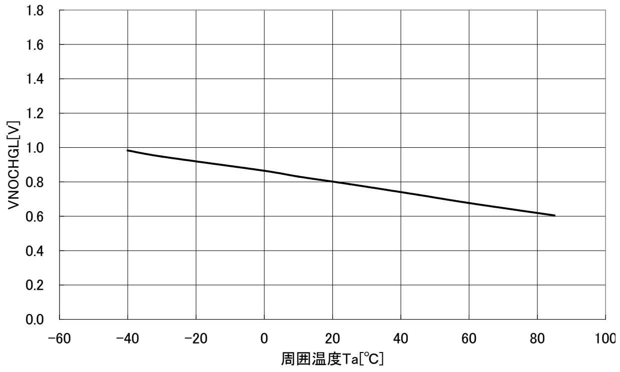


Figure 4. Over-charge Detection Voltage (CELL1) vs. Ambient Temp.

R5464x205AD

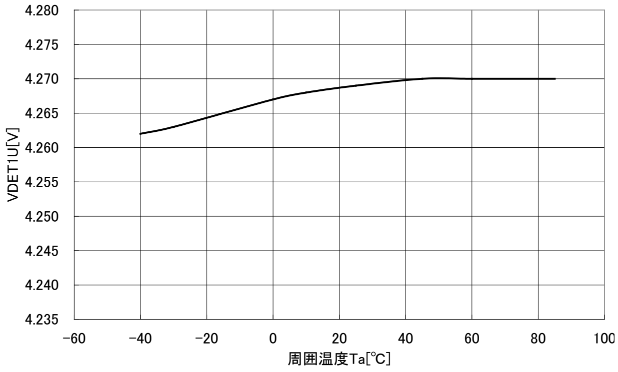


Figure 5. Over-charge Restoration Voltage (CELL1) vs. Ambient Temp.

R5464x205AD

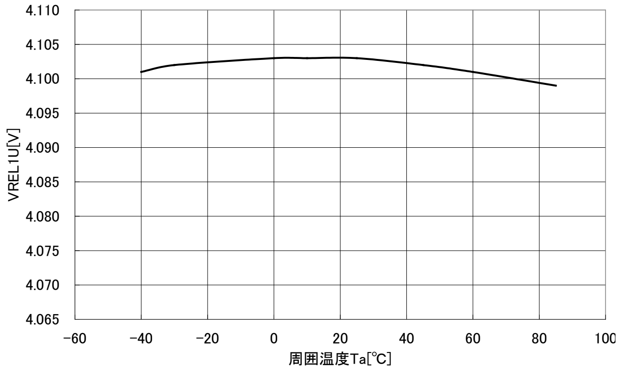


Figure 6. Over-charge Alarm Detection Voltage (CELL1) vs. Ambient Temp.

R5464x205AD

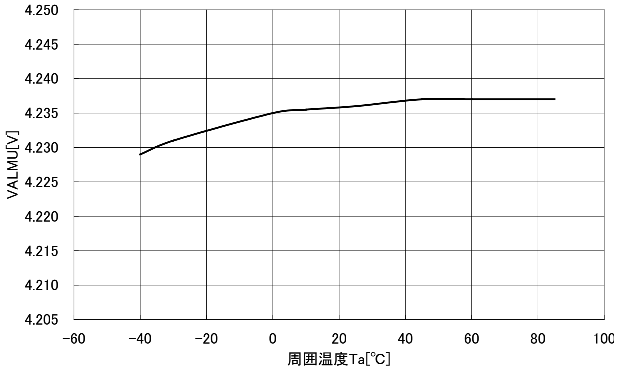


Figure 7. Over-charge Alarm Restoration Voltage (CELL1) vs. Ambient Temp.

R5464x205AD

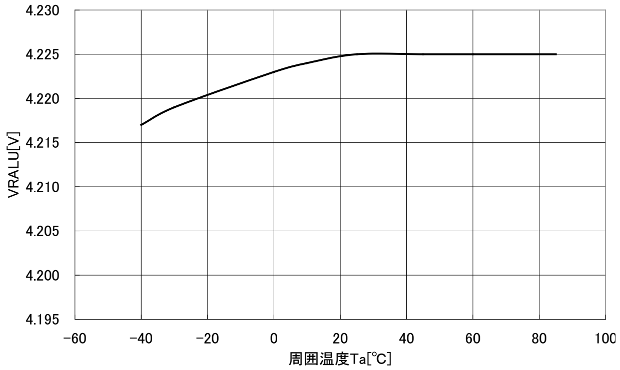


Figure 8. High Temp. Voltage Alarm Detection Voltage (CELL1) vs. Ambient Temp.

R5464x205AD

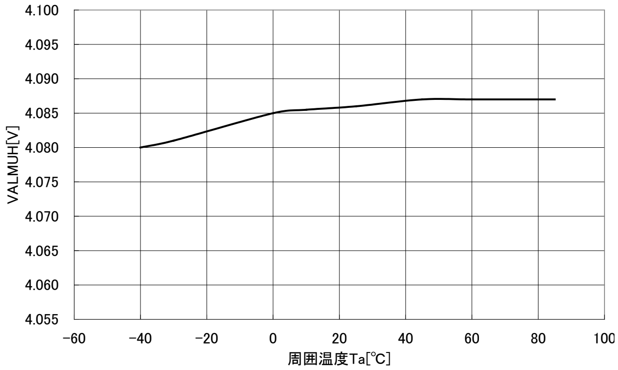


Figure 9. High Temp. Voltage Alarm Restoration Voltage (CELL1) vs. Ambient Temp.

R5464x205AD

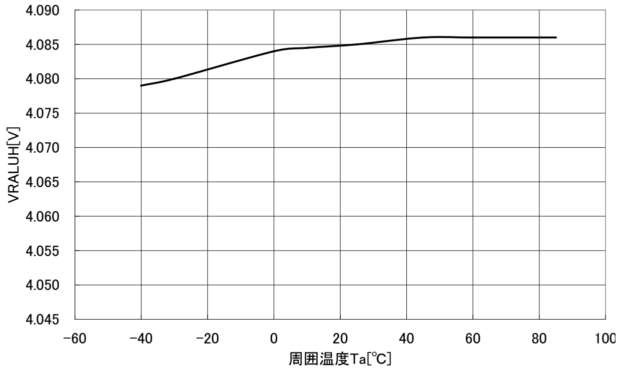


Figure 10. Over-charge Detection Voltage (CELL2) vs. Ambient Temp.

R5464x205AD

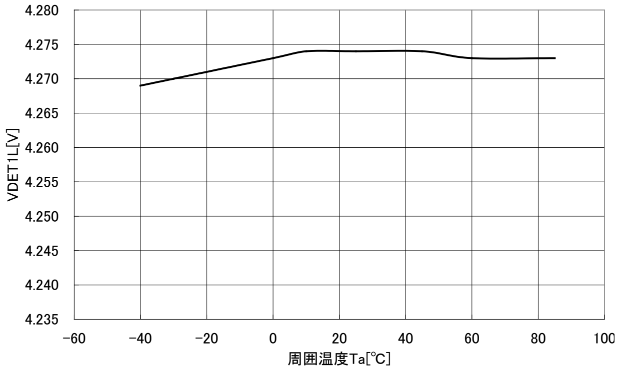


Figure 11. Over-charge Restoration Voltage (CELL2) vs. Ambient Temp.

R5464x205AD

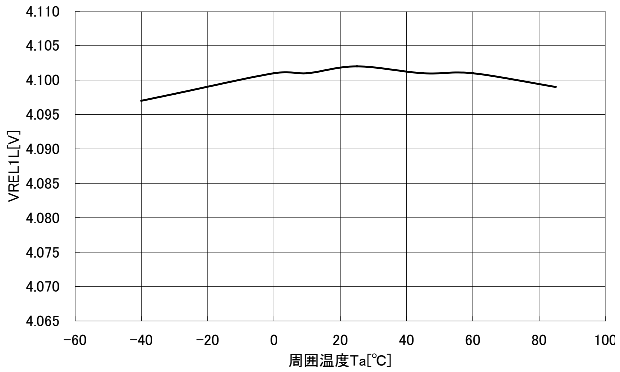


Figure 12. Over-charge Alarm Detection Voltage (CELL2) vs. Ambient Temp.

R5464x205AD

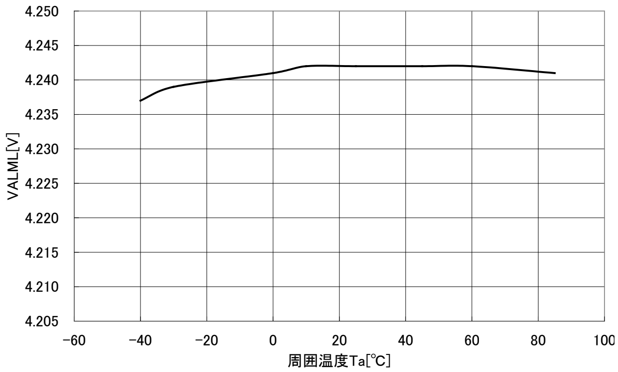


Figure 13. Over-charge Alarm Restoration Voltage (CELL2) vs. Ambient Temp.

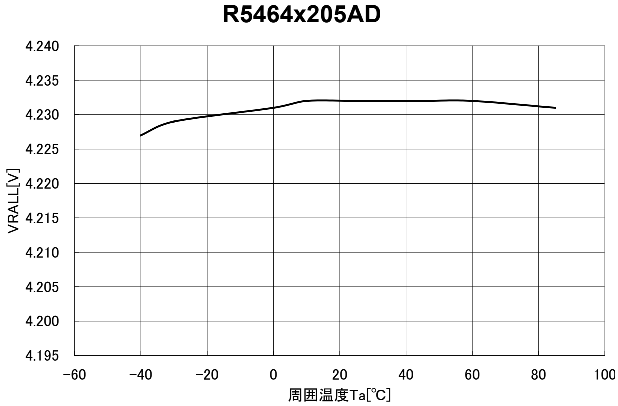


Figure 14. High Temp. Over-charge Alarm Detection Voltage (CELL2) vs. Ambient Temp.

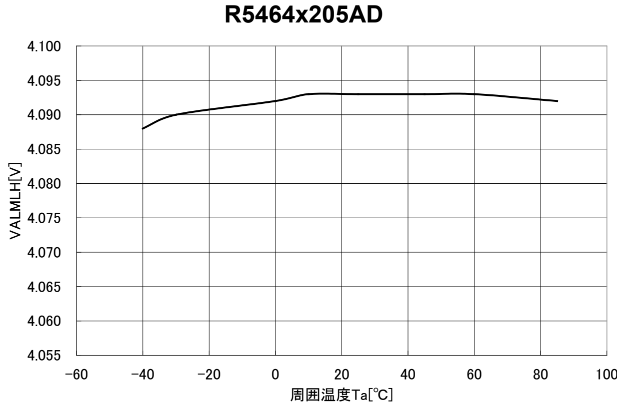


Figure 15. High Temp. Over-charge Alarm Restoration Voltage (CELL2) vs. Ambient Temp.

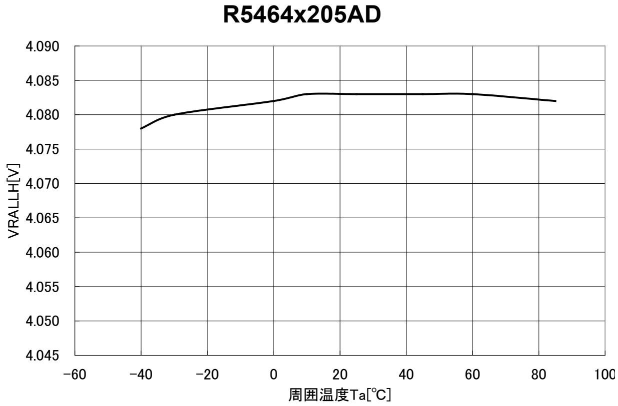


Figure 16. Over-charge Detection Delay Time vs. Ambient Temp.

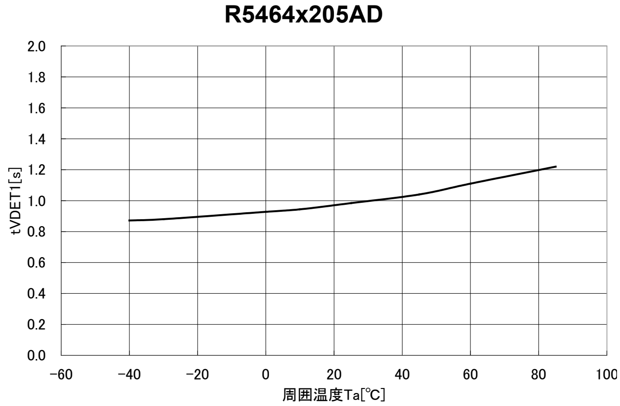


Figure 17. Over-charge Restoration Delay Time vs. Ambient Temp.

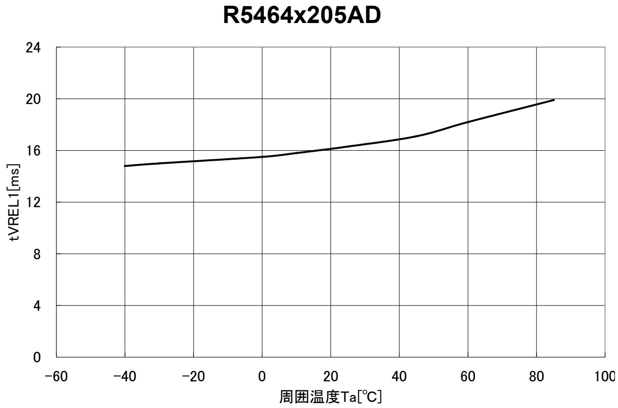


Figure 18. Alarm Detection Delay Time vs. Ambient Temp.

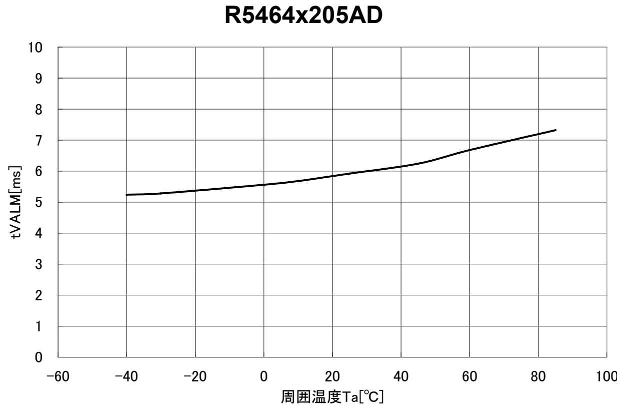


Figure 19. Alarm Restoration Delay Time vs. Ambient Temp.

R5464x205AD

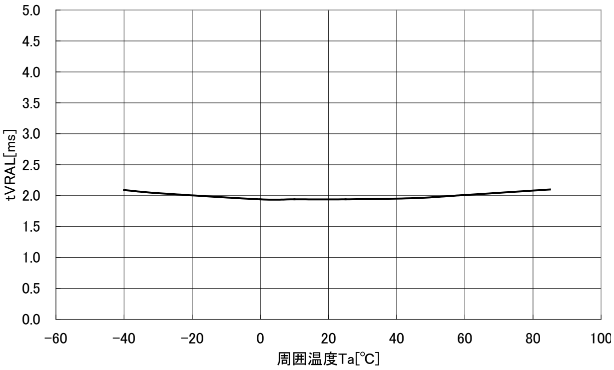


Figure 20. Over-discharge Detection Voltage (CELL1) vs. Ambient Temp.

R5464x205AD

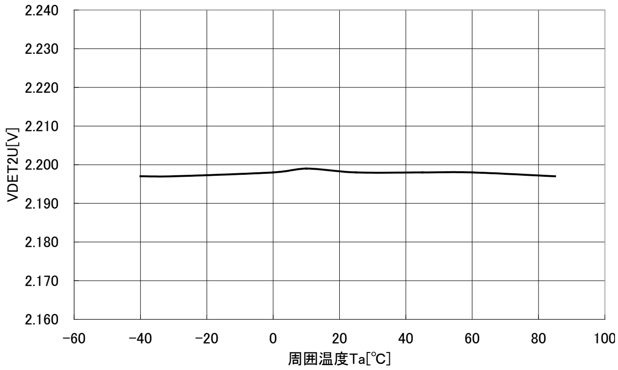


Figure 21. Over-discharge Detection Voltage (CELL2) vs. Ambient Temp.

R5464x205AD

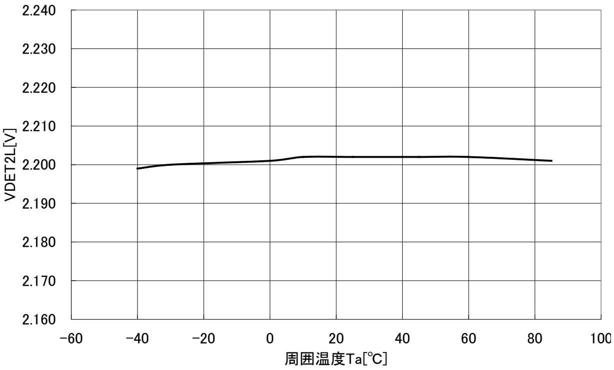


Figure 22. Over-discharge Detection Delay Time vs. Ambient Temp.

R5464x205AD

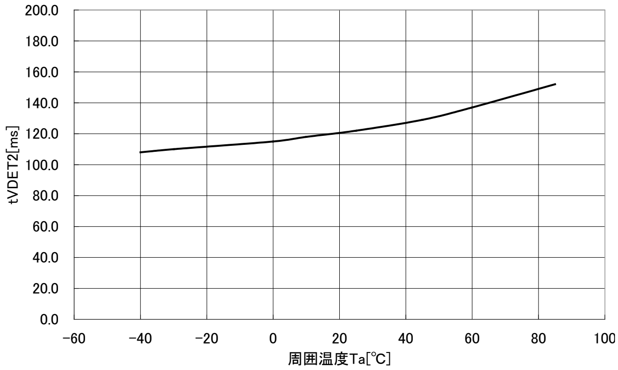


Figure 23. Over-discharge restoration Delay Time vs. Ambient Temp.

R5464x205AD

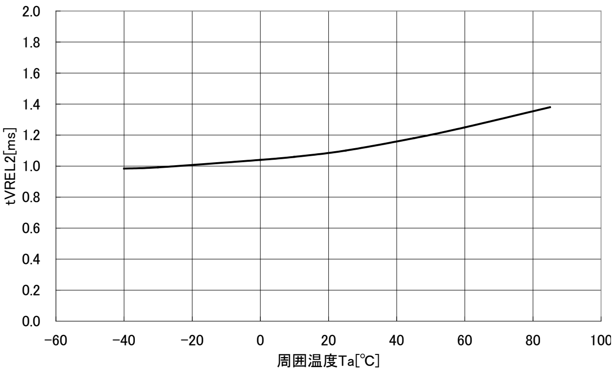


Figure 24. Discharge Overcurrent Detection Voltage vs. Ambient Temp.

R5464x205AD

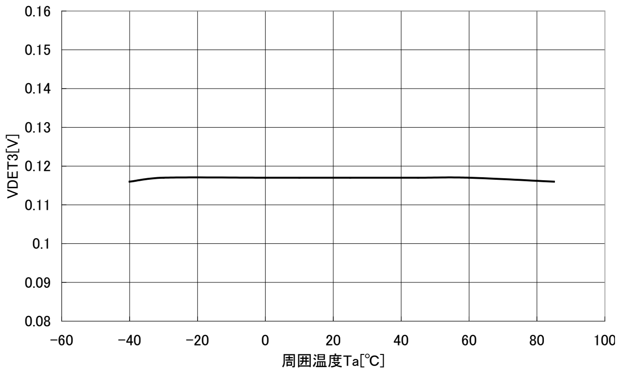


Figure 25. Discharge Overcurrent Detection Delay Time vs. Ambient Temp.

R5464x205AD

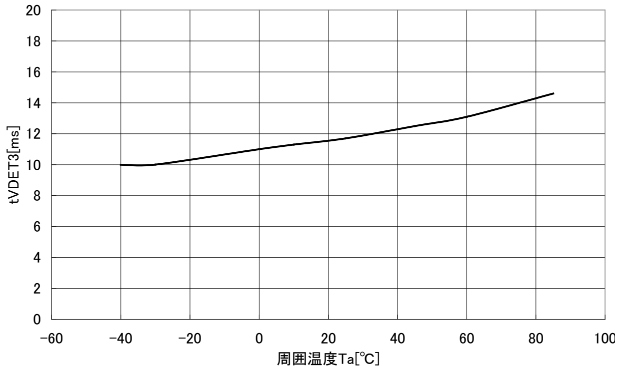


Figure 26. Discharge Overcurrent Restoration Delay Time vs. Ambient Temp.

R5464x205AD

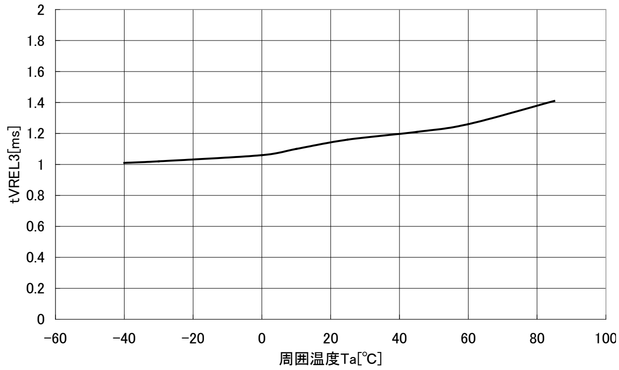


Figure 27. Short-circuit Detection Voltage vs. Ambient Temp.

R5464x205AD

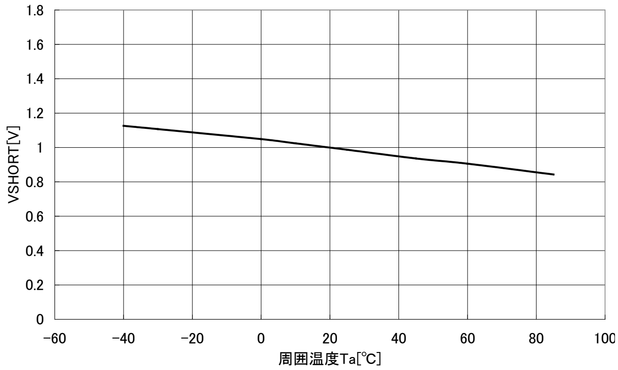


Figure 28. Short-circuit Detection Delay Time vs. Ambient Temp.

R5464x205AD

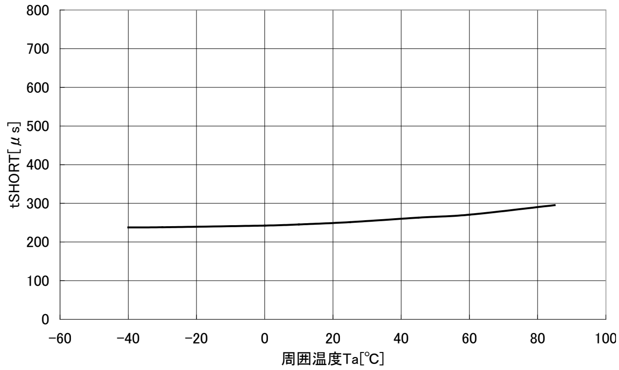


Figure 29. Discharge Overcurrent Restoration Resistance vs. Ambient Temp.

R5464x205AD

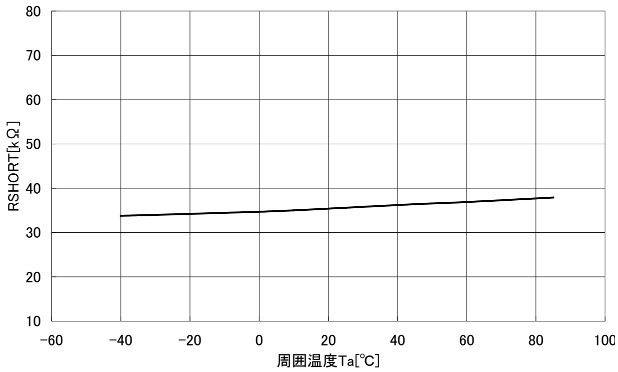


Figure 30. Charge Overcurrent Detection Voltage vs. Ambient Temp.

R5464x205AD

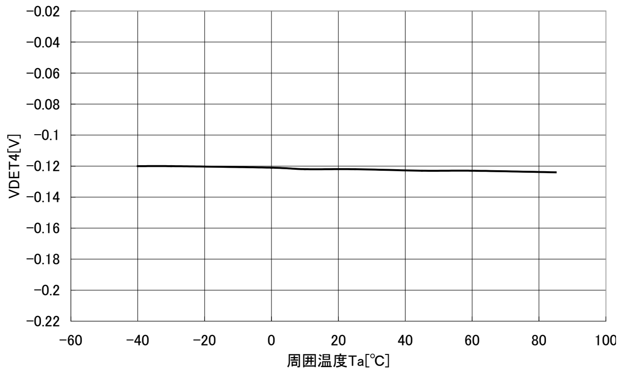


Figure 31. Charge Overcurrent Detection Delay Time vs. Ambient Temp.

R5464x205AD

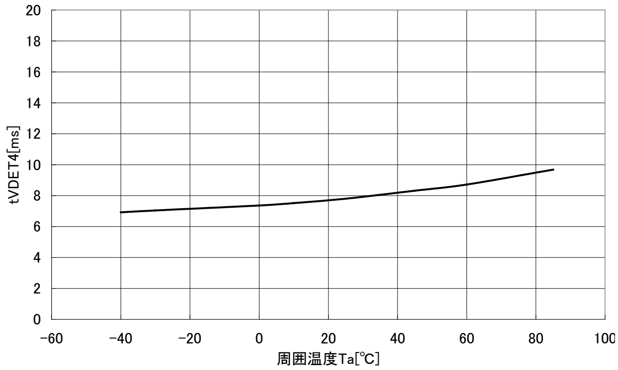


Figure 32. Charge Overcurrent Restoration Delay Time vs. Ambient Temp.

R5464x205AD

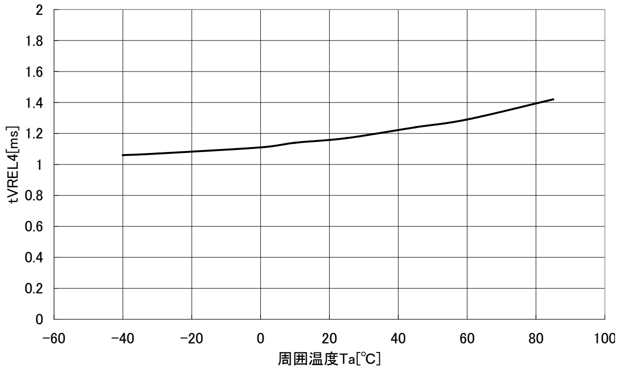


Figure 33. Delay Time Shortening Mode Voltage vs. Ambient Temp.

R5464x205AD

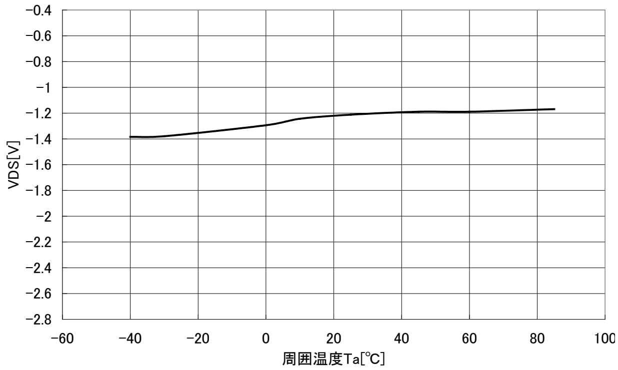


Figure 34. Nch On-voltage of COUT vs. Ambient Temp.

R5464x205AD

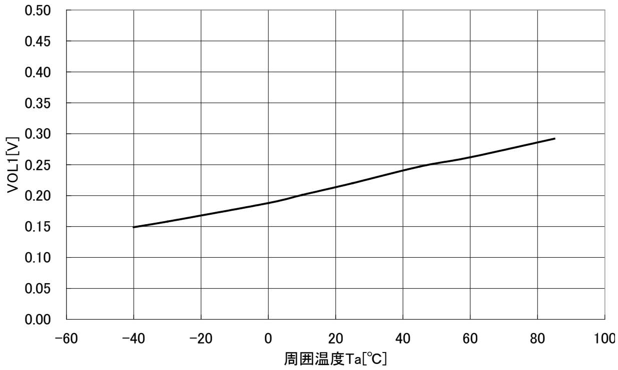


Figure 35. Pch On-voltage of COUT vs. Ambient Temp.

R5464x205AD

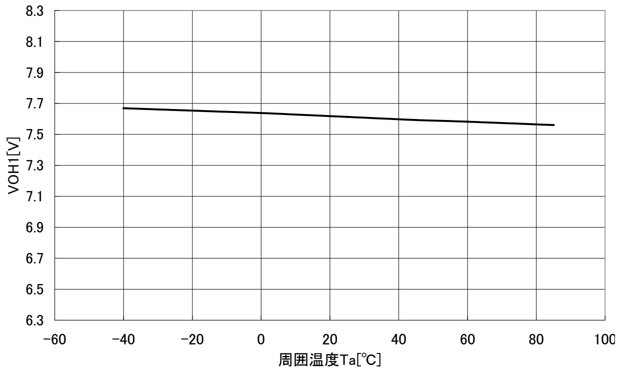


Figure 36. Nch On-voltage of DOUT vs. Ambient Temp.

R5464x205AD

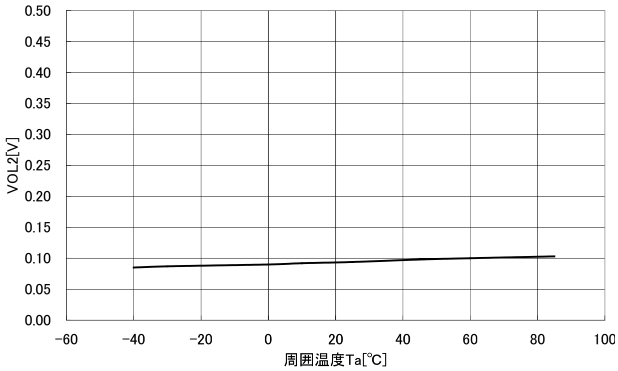


Figure 37. Pch On-voltage of DOUT vs. Ambient Temp.

R5464x205AD

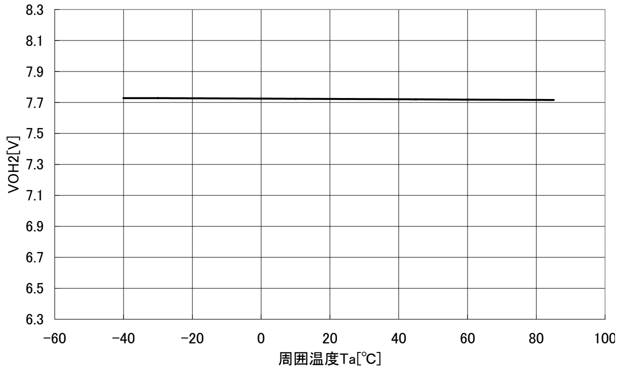


Figure 38. Pch On-voltage of AOUT vs. Ambient Temp.

R5464x205AD

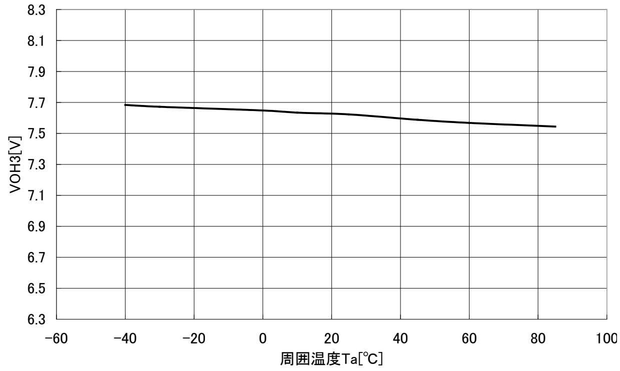


Figure 39. AOUT Pin Internal Resistance vs. Ambient Temp.

R5464x102CG

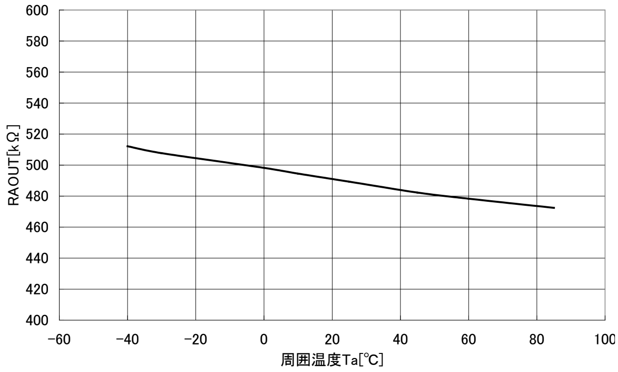


Figure 40. Supply Current (AD Version) vs. Ambient Temp.

R5464x205AD

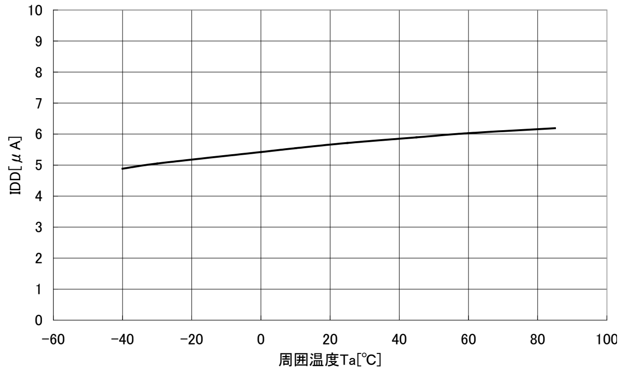


Figure 41. Supply Current (CG Version) vs. Ambient Temp.

R5464x102CG

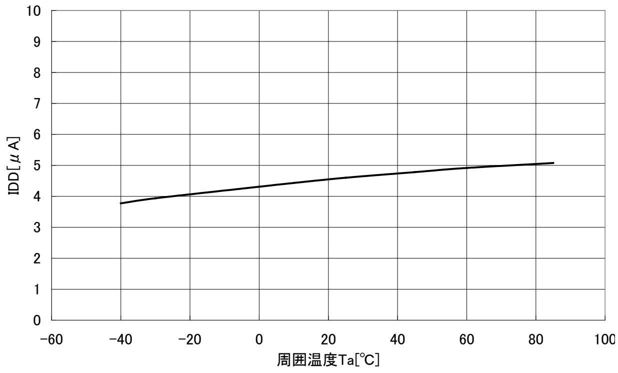
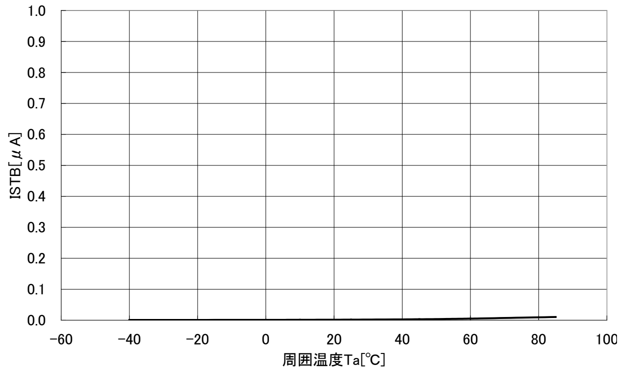


Figure 42. Standby Current vs. Ambient Temp.

R5464x205AD



Part 2: VDD Dependencies of Delay Time

Figure 1. Over-charge Detection Delay Time vs. VDD

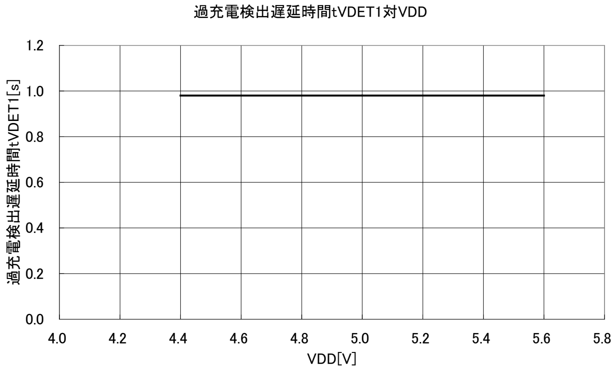


Figure 2. Over-charge Restoration Delay Time vs. VDD

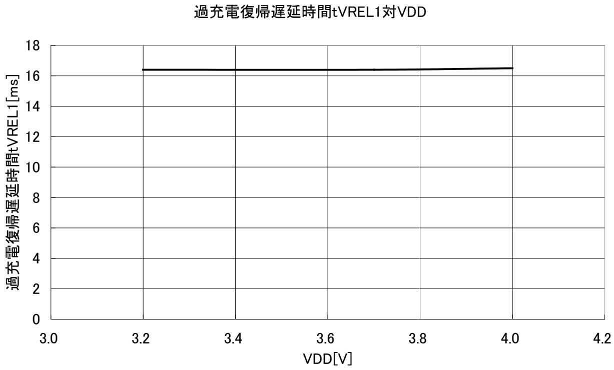


Figure 3. Over-charge Alarm Detection Delay Time vs. VDD

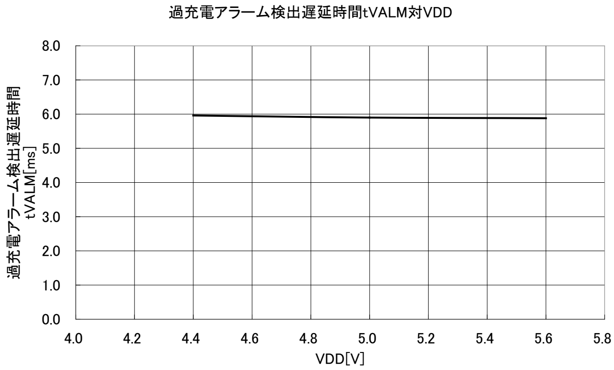


Figure 4. Over-charge Alarm Restoration Delay Time vs. VDD

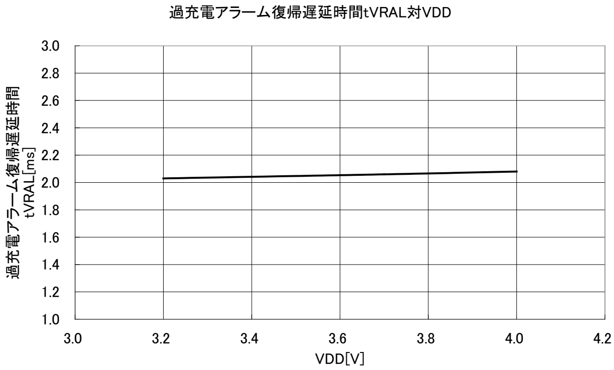


Figure 5. Over-discharge Detection Delay Time vs. VDD

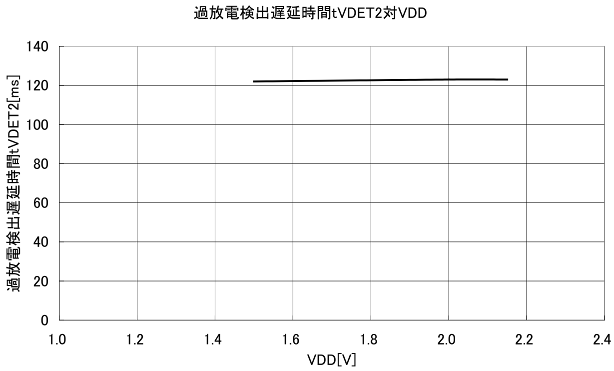


Figure 6. Over-discharge Restoration Delay Time vs. VDD

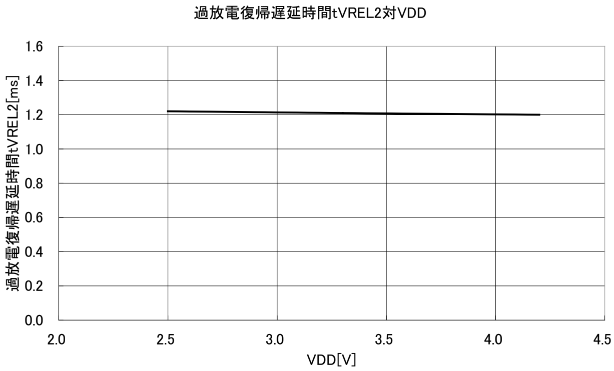


Figure 7. Discharge Overcurrent Detection Delay Time vs. VDD

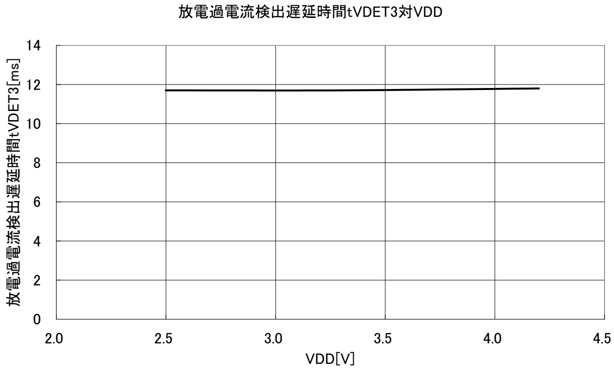


Figure 8. Discharge Overcurrent Restoration Delay Time vs. VDD

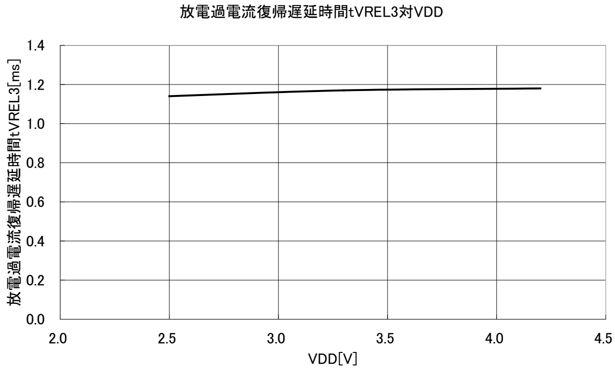


Figure 9. Charge Overcurrent Detection Delay Time vs. VDD

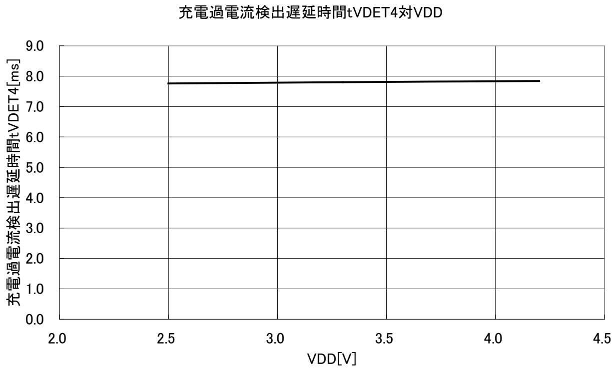


Figure 10. Charge Overcurrent Restoration Delay Time vs. VDD

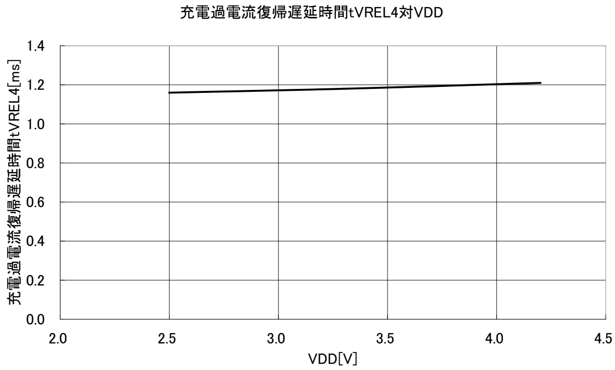
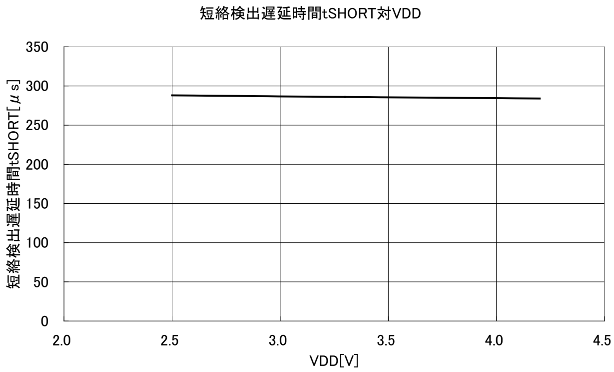
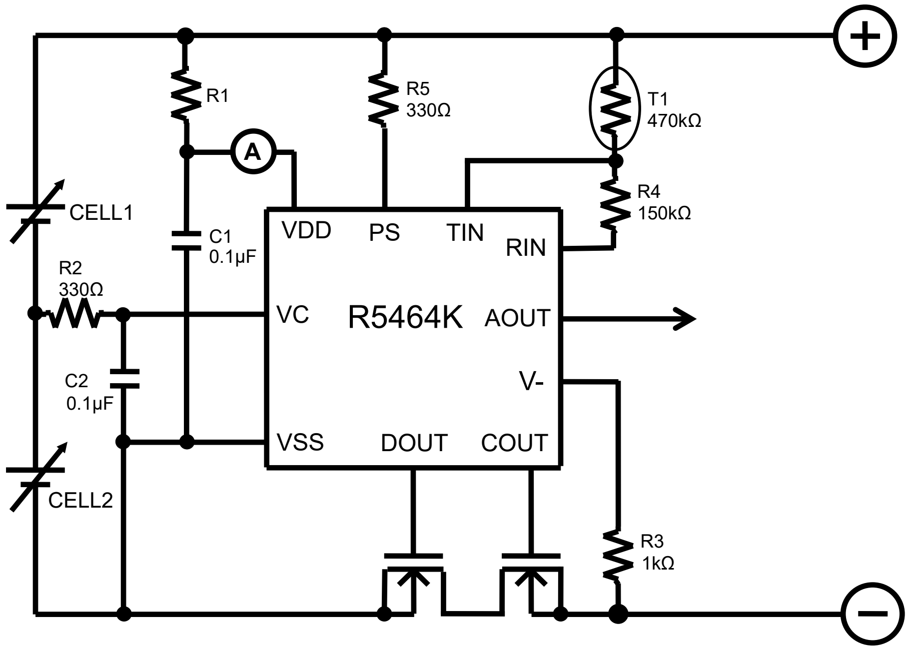


Figure 11. Short-circuit Detection Delay Time vs. VDD



Part 3: VDD Dependence of Supply Current

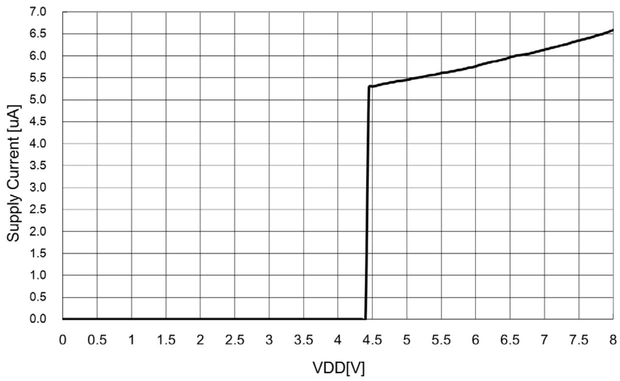
Test Circuit



D Version

VDD Dependency of Supply Current

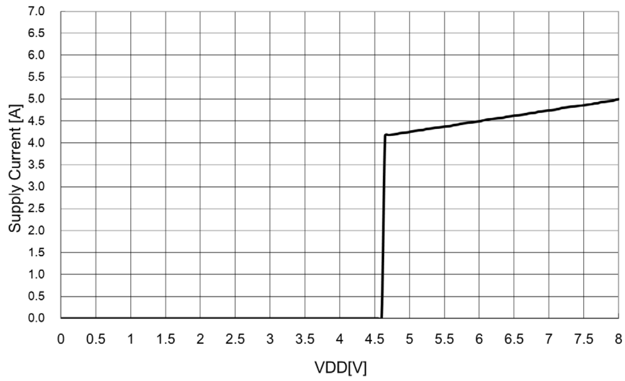
R5464x205AD



G Version

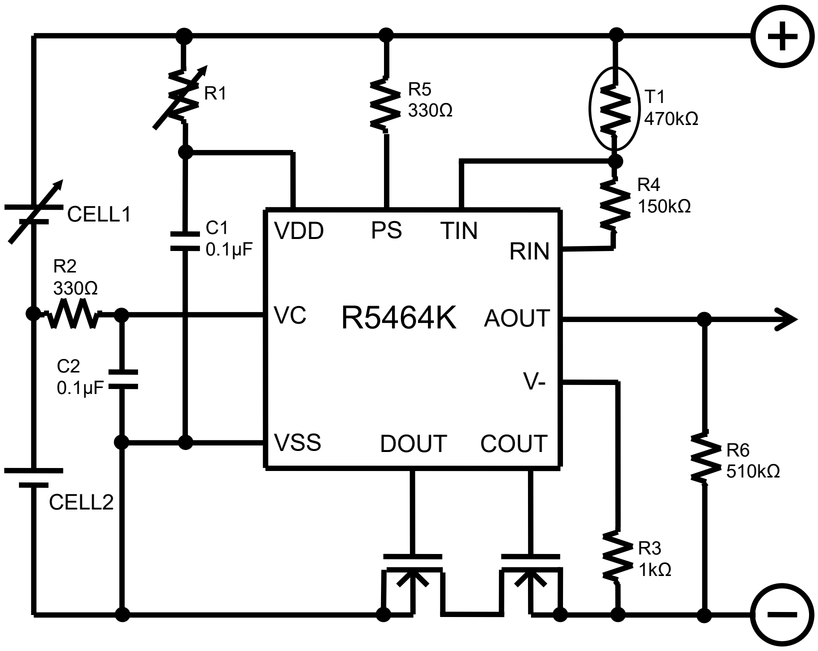
VDD Dependency of Supply Current

R5464x102CG



Part 4: External Resistance (R1) Dependence of Overcharge Alarm Detection/ Restoration Voltage, Overcharge Detection/ Restoration Voltage, Overdischarge Detection/ Restoration Voltage

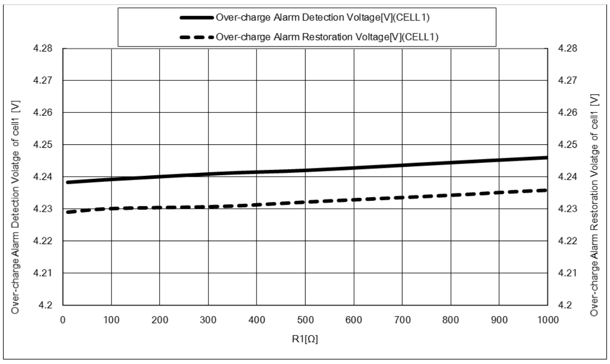
Test Circuit



D Version

Overcharge Alarm Detection/ Restoration Voltage vs. R1 (CELL1)

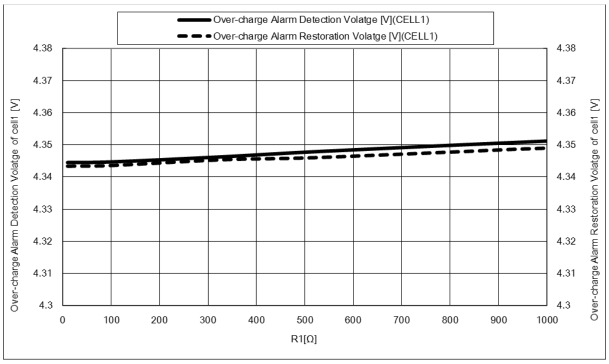
R5464x205AD



G Version

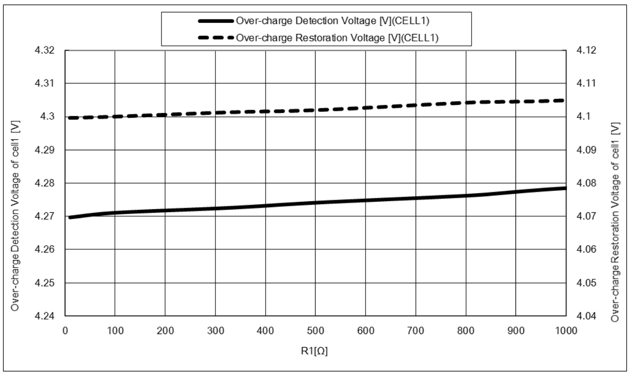
Overcharge Alarm Detection/ Restoration Voltage vs. R1 (CELL1)

R5464x102CG



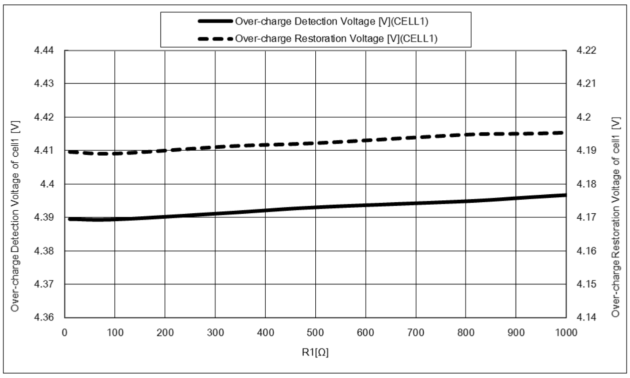
D Version

Overcharge Detection/ Restoration Voltage vs. R1 (CELL1)
R5464x205AD



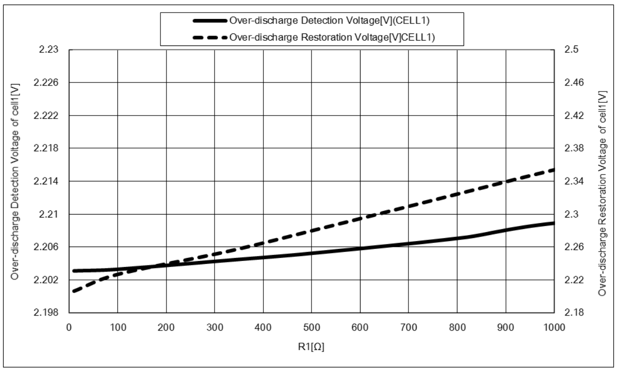
G Version

Overcharge Detection/ Restoration Voltage vs. R1 (CELL1)
R5464x102CG



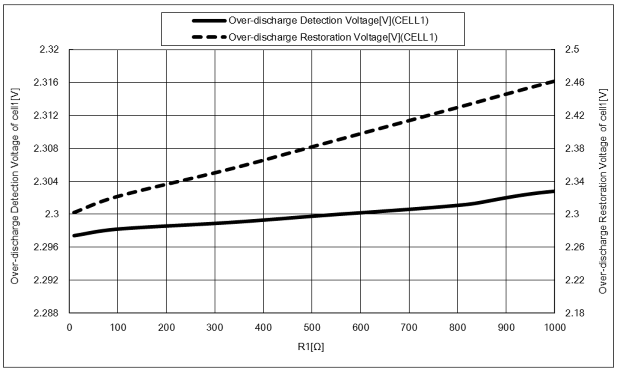
D Version

Overdischarge Detection Voltage vs. R1 (CELL1)
R5464x205AD



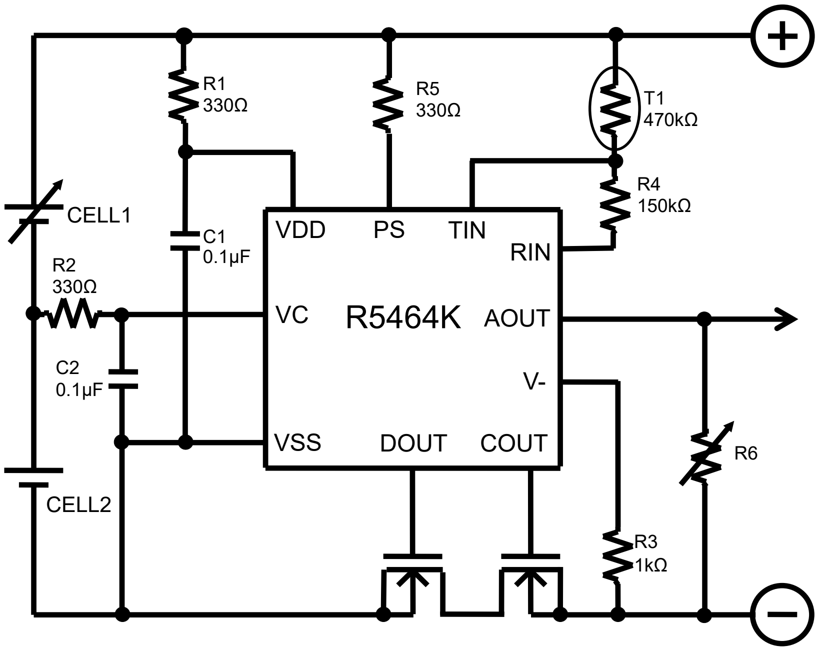
G Version

Overdischarge Detection Voltage vs. R1 (CELL1)
R5464x102CG



Part 5: External Resistance (R6) Dependence of Over-charge Alarm Detection/ Restoration Voltage

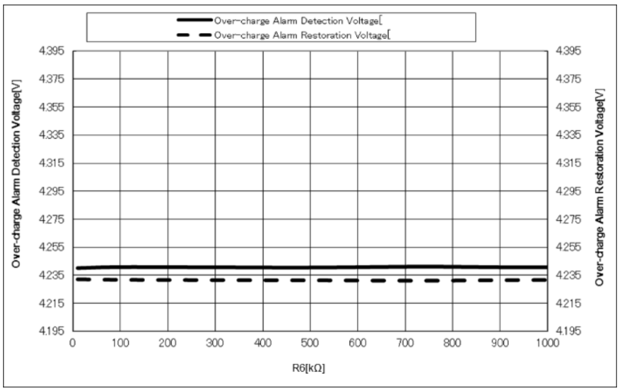
Test Circuit



D Version

Over-charge Alarm Detection/ Restoration Voltage vs. R6 (CELL1)

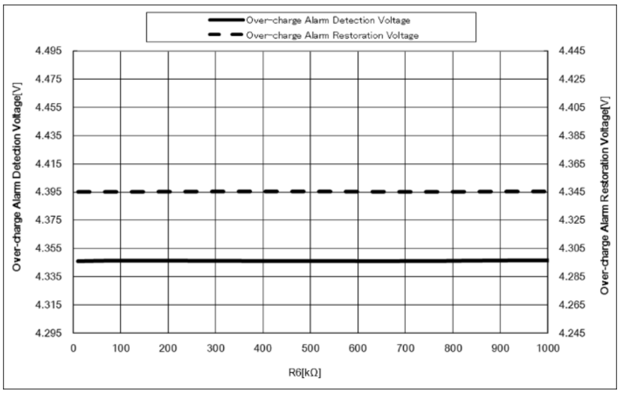
R5464x205AD



G Version

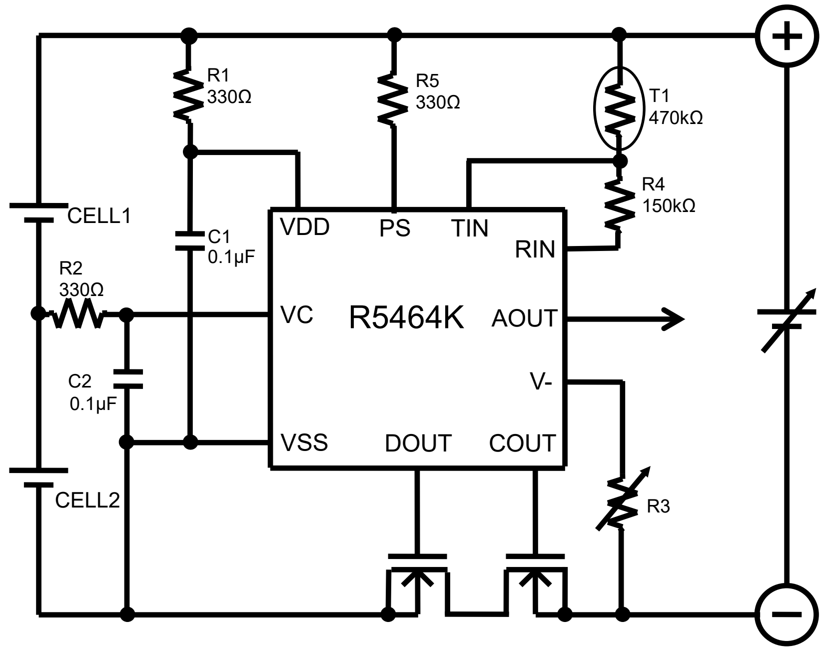
Over-charge Alarm Detection/ Restoration Voltage vs. R6 (CELL1)

R5464x102CG



Part 6: External Resistance (R3) Dependence of Charger Voltage at Recovery from Over-discharge

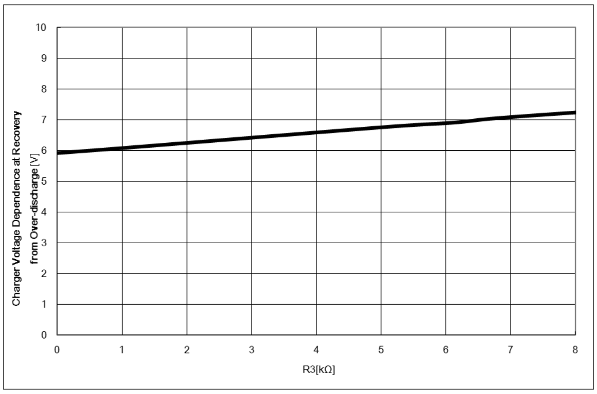
Test Circuit



D Version

Charger Voltage at Recovery from Over-discharge vs. R3

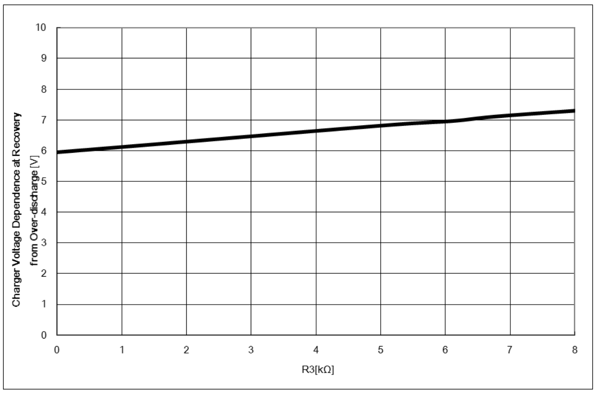
R5464x205AD



G Version

Charger Voltage at Recovery from Over-discharge vs. R3

R5464x102CG



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).

PD-DFN(PL)2527-10-(85125)-JE-A

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

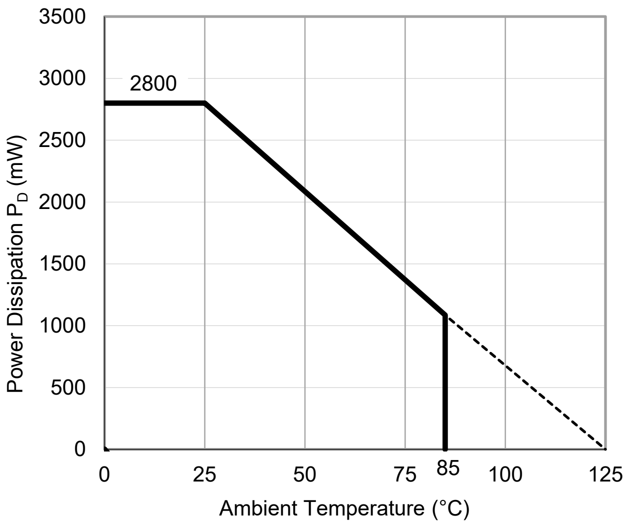
Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square
Through-holes	ϕ 0.3 mm × 30 pcs

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

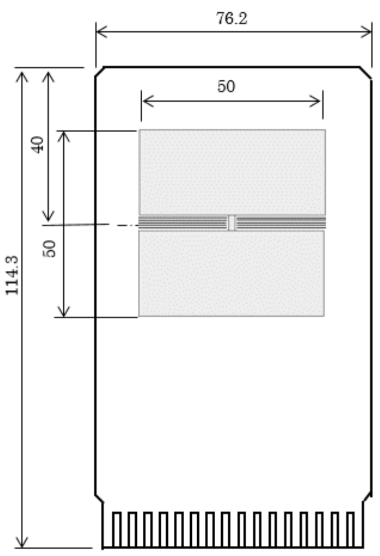
Item	Measurement Result
Power Dissipation	2800 mW
Thermal Resistance (θja)	θja = 35°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 10°C/W

θja: Junction-to-Ambient Thermal Resistance

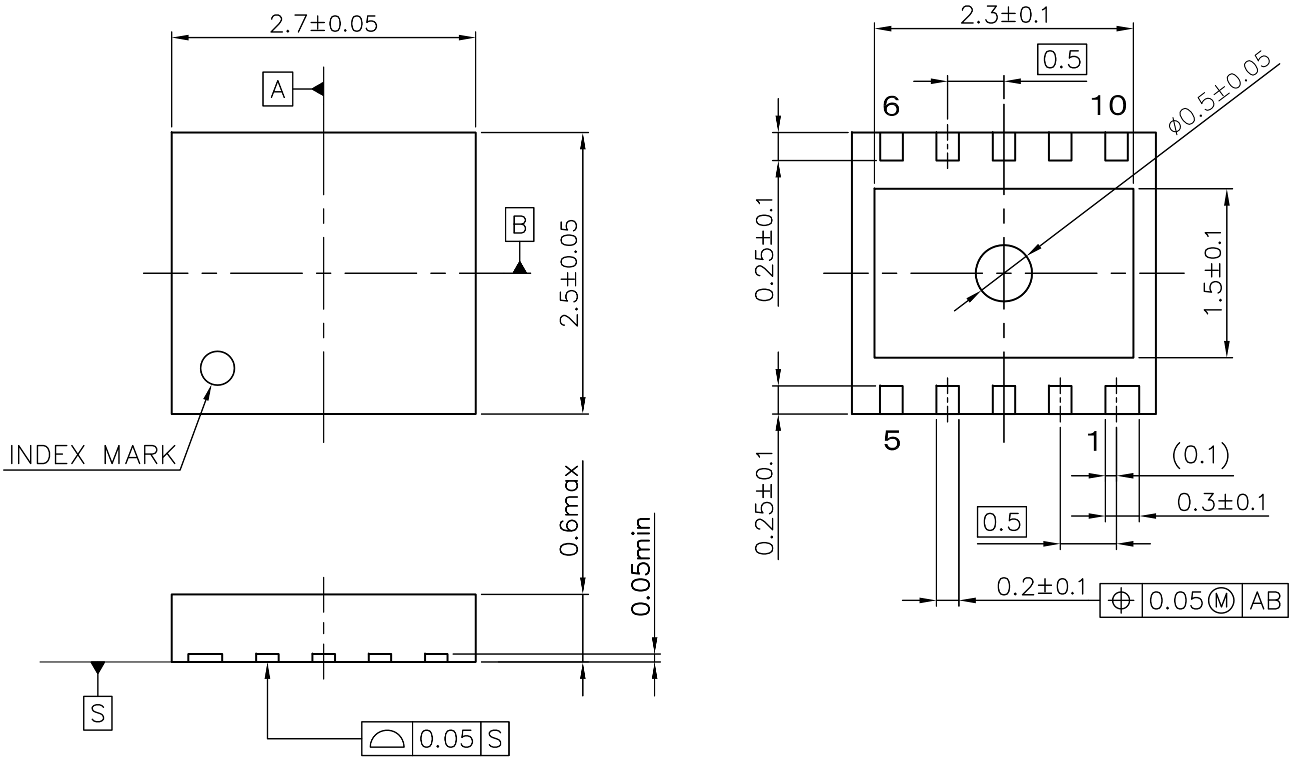
ψjt: Junction-to-Top Thermal Characterization Parameter



Power Dissipation vs. Ambient Temperature



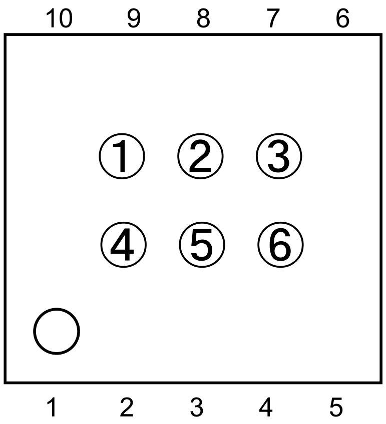
Measurement Board Pattern



DFN(PL)2527-10 Package Dimensions (mm)

①②③④: Product Code ··· Refer to *Part Marking List*

⑤⑥: Lot Number ··· Alphanumeric Serial Number



R5464K [DFN(PL)2527-10] Part Marking

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

R5464Kxxxxx Part Marking List

Product Name	①②③④
R5464K201AD	D R 0 0
R5464K102CG	D R 0 1
R5464K204AD	D R 0 2
R5464K205AD	D R 0 3
R5464K203AD	D R 0 4
R5464K206AD	D R 0 5
R5464K207AD	D R 0 6
R5464K208AD	D R 0 7
R5464K109CG	D R 0 8
R5464K110CG	D R 0 9
R5464K213AD	D R 1 0
R5464K212DD	D R 1 1
R5464K214AD	D R 1 2
R5464K215AD	D R 1 3
R5464K216AD	D R 1 4

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