

# **R5487L/R5497L Series**

# 1 Cell Li-ion/Li-polymer Protector

NO. EA-357-191125

## **OUTLINE**

The R5487L/R5497L Series are high voltage tolerance CMOS-based protection IC for over-charge/discharge and over-current of rechargeable one-cell Lithium-ion (Li+)/Lithium polymer battery. The R5487L/R5497L Series can detect over-charge/discharge of Li+ one-cell and excess load current, further include a short circuit protector for preventing large external short circuit current and the excess charge-current.

The R5487L/R5497L Series are composed of four voltage detectors, reference units, a delay circuit, a short circuit protector, an oscillator, a counter, and logic circuits.

The output of Over-charge detector or Excess charge-current detector switches to "L" level after internally fixed delay time, when charged voltage crosses the detector threshold from a low value to a high value.

They have two types to release Over-charge detector. The one is called "Latch type". The output of Cout switches to "H" when a kind of load is connected to battery pack after a charger is disconnected from the battery pack, and the cell voltage becomes lower than over-charge detector threshold.

The other is called "Auto Release type". The output of Cout switches to "H", when the cell voltage is lower than over-charge detector release threshold, or by disconnecting a charger when the battery voltage is lower than over-charge detector threshold.

The output of Over-discharge detector or 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 VDETZ.

They have two types to release Over-discharge detector. The one is called "Latch type". In the case that a charger is connected to the battery pack, and  $V_{DD}$  level is more than over-discharge detector threshold, the output level of  $D_{OUT}$  becomes "H" immediately. The other is called "Auto Release type". In the case that a charger is connected to the battery pack, and  $V_{DD}$  level is more than over-discharge detector threshold, the output level of  $D_{OUT}$  becomes "H" immediately. Without connecting a charger, if  $V_{DD}$  pin voltage is equal or more than the released voltage from over-discharge, the output level of  $D_{OUT}$  becomes "H".

An excess discharge-current and short circuit state can be sensed and cut off through the built in excess current detector with Dout being enabled to low level. Once after detecting excess discharge-current or short circuit is released and Dout level switches to high by detaching a load system from a battery pack.

After detecting over-discharge, 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 Vss-2V or lower, the delay time of detector can be shortened. Especially, the delay time of over-charge detector can be reduced into approximately 1/60. Therefore, testing time of protector circuit board can be reduced. Output type of Cout and Dout are CMOS. The R5487L/R5497L Series have DFN1414-6B and DFN1814-6B.

#### **FEATURES**

#### **Manufactured with High Voltage Tolerant Process**

Absolute Maximum Rating ......30 V

#### **Low Supply Current**

- Supply current (At normal mode) ......Typ. 3.0 μA

#### **High Accuracy Detector Threshold**

• Over-charge detector ......±20 mV (Ta = 25°C)

 $\pm 25 \text{ mV } (-20^{\circ}\text{C} \le \text{Ta} \le 60^{\circ}\text{C})$ 

- Over-discharge detector ......±35 mV
- Excess discharge-current detector (VDET3) .....±10 mV (V<sub>DET3</sub> ≥ 0.100 V)

 $\pm 10\% (0.050 \text{ V} \leq \text{V}_{\text{DET31}} < 0.100 \text{ V})$ 

 $\pm 5 \text{ mV (V}_{DET31} < 0.050 \text{ V)}$ 

• Excess charge-current detector (VDET4)..... $\pm 10\%$  (V<sub>DET4</sub>  $\leq -0.05$  V)

 $\pm 5 \text{ mV (V}_{DET4} > -0.05 \text{ V)}$ 

#### **Variety of Detector Threshold**

- Over-charge detector threshold .......4.2 V to 4.6 V, 0.005 V step
- Over-discharge detector threshold ......2.0 V to 3.0 V, 0.100 V step
- Over-discharge release threshold......2.4 V to 3.2 V, 0.100 V step

#### **Internal Fixed Output Delay Time**

- Over-charge detector Output Delay......1.0 s
- Over-discharge detector Output Delay ......20 ms
- Excess discharge-current detector Output Delay .. 12 ms
- Excess charge-current detector Output Delay ...... 8 ms
- Short Circuit detector Output Delay ......250 μs

#### **Output Delay Time Shortening Function**

At C<sub>OUT</sub> is "H", if V- level is set at typically –2V, the Output Delay time of all items except short-circuit can be reduced (Delay Time for over-charge becomes about 1/60 of normal state).

#### **Selectable Functions**

- 0V-battery charge option......Acceptable/Unacceptable
- Conditions for release over-charge detector.....Latch type/Auto Release type
- Conditions for release over-discharge detector .....Latch type/Auto Release type
- Conditions for release short-current detector ........Type 1/Type 2<sup>(1)</sup>

#### Ultra Small Package

• The R5487L/R5497L Series have DFN1414-6B and DFN1814-6B.

Type 1: more than 300 k $\Omega$  Type 2: more than 25 k $\Omega$ 

**RICOH** 

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 $<sup>^{(1)}</sup>$  Load Resistance Threshold for release from Over-Discharge Current Status (Ta = 25 $^{\circ}$ C)

# **APPLICATIONS**

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

# **SELECTION GUIDE**

The voltage code, on, and package for the ICs can be selected by the user's request.

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free	
R5487Lyxx \$*-TR	DFN1414-6B ⇒ wiring A	5,000 pcs	Yes	Yes	
R5497Lyxx \$*-TR	DFN1414-6B ⇒ wiring B	5,000 pcs	Yes	Yes	
R5487Lyxx \$*-TR	DFN1814-6B	5,000 pcs	Yes	Yes	

yxx: Set Voltage Code. Refer to *Product Code List*.

In the case of DFN1414-6B, y: 5 to 8, In the case of DFN1814-6B, y: 1 to 4

#### Delay Time Code

\$:	Delay Time Code											
	Code	t <sub>VDET1</sub> (s)	t <sub>VDET2</sub> (ms)	t <sub>VDET3</sub> (ms)	t <sub>VDET4</sub> (ms)	t <sub>SHORT</sub> (μ <b>s</b> )						
	K	1	20	12	8	250						
	S	1	20	128	17	250						

#### **Function Code**

	Function Code								
:	Code	Over-Charge	Over-Discharge	Excess-discharge-current (1)	0V Charge				
	D	Auto-Release	Auto-Release	Auto-Release Type 1	OK				
	F	Auto-Release	Auto-Release	Auto-Release Type 1	NG				
	М	Auto-Release	Auto-Release	Auto-Release Type 2	OK				
	Р	Auto-Release	Auto-Release	Auto-Release Type 2	NG				
	Q	Latch	Latch	Auto-Release Type 2	OK				

Type 1: more than 300 k $\Omega$ 

Type 2: more than 25 k $\Omega$ 

 $<sup>^{(1)}</sup>$  Load Resistance Threshold for release from Over-Discharge Current Status (Ta = 25 $^{\circ}$ C)

# **Product Code List**

# **Product Code Table**

Code	V <sub>DET1</sub>	V <sub>REL1</sub>	V <sub>DET2</sub>	V <sub>REL2</sub>	V <sub>DET3</sub>	V <sub>DET4</sub>	V <sub>SHORT</sub>	tvDET1	tvDET2	tvDET3	tvDET4	tshort	0-V
	(V)	(s)	(ms)	(ms)	(ms)	(µs)	Charge						
R5487L : DFN	1814-6E	3	1		•	1	1	•			r		
R5487L102KD	4.475	4.275	2.500	2.900	0.065	-0.050	0.200	1	20	12	8	250	OK
R5487L102KP	4.475	4.275	2.500	2.900	0.065	-0.050	0.200	1	20	12	8	250	NG
R5487L103KM	4.425	4.225	2.500	2.900	0.100	-0.050	0.300	1	20	12	8	250	OK
R5487L105KD	4.475	4.275	2.500	2.900	0.130	-0.130	0.200	1	20	12	8	250	OK
R5487L106KD	4.400	4.100	2.500	2.800	0.043	-0.043	0.200	1	20	12	8	250	OK
R5487L107KD	4.425	4.225	2.800	3.000	0.090	-0.045	0.220	1	20	12	8	250	OK
R5487L111KD	4.425	4.225	2.500	2.800	0.130	-0.100	0.400	1	20	12	8	250	OK
R5487L113KD	4.280	4.080	2.600	2.700	0.075	-0.050	0.200	1	20	12	8	250	OK
R5487L114KD	4.280	4.080	2.600	2.700	0.050	-0.050	0.150	1	20	12	8	250	OK
R5487L116KD	4.475	4.275	2.500	2.900	0.032	-0.020	0.150	1	20	12	8	250	OK
R5487L116KM	4.475	4.275	2.500	2.900	0.032	-0.020	0.150	1	20	12	8	250	OK
R5487L117KP	4.450	4.250	2.500	2.900	0.100	-0.100	0.300	1	20	12	8	250	NG
R5487L118KM	4.415	4.215	2.500	2.900	0.045	-0.045	0.200	1	20	12	8	250	OK
R5487L119KM	4.420	4.220	2.500	2.900	0.050	-0.040	0.200	1	20	12	8	250	OK
R5487L120KP	4.475	4.275	2.500	2.900	0.045	-0.040	0.150	1	20	12	8	250	NG
R5487L121SD	4.550	4.250	2.000	2.400	0.030	-0.035	0.200	1	20	128	17	250	OK
R5487L122KM	4.470	4.270	2.500	2.900	0.050	-0.030	0.150	1	20	12	8	250	OK
R5487L123KM	4.475	4.275	2.500	2.900	0.055	-0.050	0.150	1	20	12	8	250	OK
R5487L124KD	4.475	4.275	2.500	2.900	0.065	-0.065	0.250	1	20	12	8	250	OK
R5487L125KD	4.550	4.350	2.300	2.500	0.065	-0.065	0.250	1	20	12	8	250	OK
R5487L126KF	4.470	4.270	2.800	3.000	0.047	-0.042	0.200	1	20	12	8	250	NG
R5487L127KD	4.475	4.275	2.500	2.900	0.065	-0.065	0.400	1	20	12	8	250	OK
R5487L128KF	4.470	4.270	2.800	3.000	0.045	-0.045	0.200	1	20	12	8	250	NG
R5487L129KP	4.525	4.325	2.500	2.900	0.055	-0.050	0.250	1	20	12	8	250	NG
R5487L130KP	4.470	4.270	2.500	2.800	0.045	-0.045	0.200	1	20	12	8	250	NG
R5487L135KP	4.500	4.300	2.500	2.900	0.045	-0.040	0.150	1	20	12	8	250	NG
R5487L137KP	4.550	4.300	2.500	2.900	0.045	-0.030	0.150	1	20	12	8	250	NG
R5487L142KQ	4.475	_	2.500	_	0.055	-0.050	0.150	1	20	12	8	250	ОК

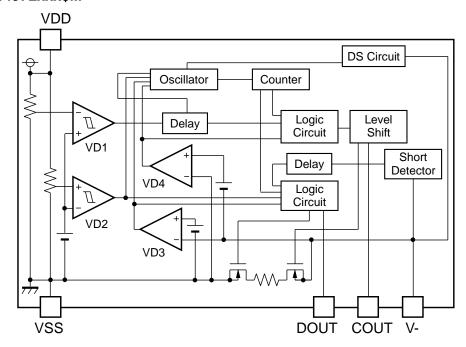
NO. EA-357-191125

# **Product Code Table (Continued)**

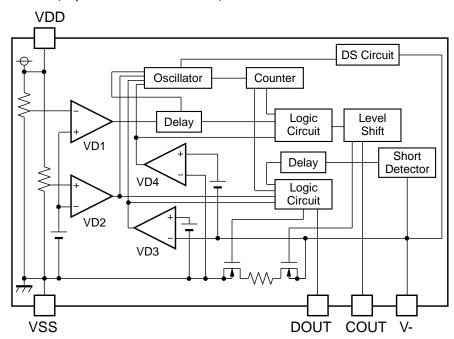
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Code	V <sub>DET1</sub>	V <sub>REL1</sub>	V <sub>DET2</sub>	V <sub>REL2</sub>	V <sub>DET3</sub>	V <sub>DET4</sub> (V)	V <sub>SHORT</sub>	t <sub>VDET1</sub>	t <sub>VDET2</sub>	t <sub>VDET3</sub>	t <sub>VDET4</sub> (ms)	t <sub>SHORT</sub>	0-V Charge
R5487L301KM		4.215	2.500	2.900		-0.080	0.300	1	20	12	8	250	OK
R5487L302KP	4.475	4.275	2.500	2.900	0.130	-0.100	0.300	1	20	12	8	250	NG
R5487L303KM	4.475	4.275	2.500	2.900	0.130	-0.130	0.300	1	20	12	16	250	OK
R5487L304KM	4.475	4.275	2.800	3.000	0.150	-0.130	0.300	1	20	12	16	250	OK
R5487L305KQ	4.475	-	2.500	-	0.130	-0.100	0.300	1	20	12	8	250	OK
R5487L306KQ	4.475	-	2.500	-	0.130	-0.065	0.300	1	20	12	8	250	OK
R5487L307KM	4.475	4.275	2.500	2.900	0.080	-0.070	0.200	1	20	12	16	250	OK
R5487L308KM	4.475	4.275	2.500	2.900	0.100	-0.080	0.300	1	20	12	16	250	OK
R5487L309KP	4.475	4.275	2.600	3.000	0.150	-0.100	0.400	1	20	12	8	250	NG
R5487L311KP	4.475	4.275	2.400	2.800	0.075	-0.075	0.250	1	20	12	8	250	NG
R5487L314KP	4.280	4.180	2.800	2.900	0.150	-0.100	0.300	1	20	12	8	250	NG
R5487L316KM	4.250	4.100	2.800	3.100	0.070	-0.030	0.200	1	20	12	16	250	OK
R5487L401KP	4.475	4.275	2.500	2.900	0.032	-0.030	0.150	1	20	12	8	250	NG
R5487L402KP	4.425	4.225	2.500	2.900	0.032	-0.030	0.150	1	20	12	8	250	NG
R5487L : DFN1	414-6B	3											
R5487L504KM	4.425	4.225	2.500	2.900	0.032	-0.020	0.150	1	20	12	8	250	OK
R5497L : DFN1	414-6B	3											
R5497L501KF	4.425	4.225	2.500	3.000	0.035	-0.020	0.150	1	20	12	16	250	NG
R5497L509KF	4.275	4.075	2.500	3.000	0.035	-0.020	0.150	1	20	12	16	250	NG
R5497L540KF	4.475	4.275	2.800	3.000	0.050	-0.050	0.150	1	20	12	16	250	NG

# **BLOCK DIAGRAMS**

 R5487L/R5497Lxxx\$D, R5487L/R5497Lxxx\$F, R5487L/R5497Lxxx\$P, R5487L/R5497Lxxx\$M



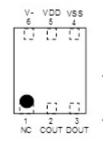
• R5487L/R5497Lxxx\$Q, R5487L/R5497Lxxx\$L



# **PIN DESCRIPTIONS**

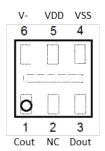
DFN1814-6B

R5487Lyxxxx (y:1 to 4)



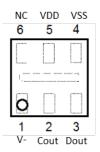
**DFN1414-6B** ⇒wiring A

R5487Lyxxxx (y:5 to 8)



DFN1414-6B

⇒wiring B R5497Lyxxxx (y:5 to 8)



# R5487L/R5497L Pin Configurations

	Pin No.							
R54	R5487L DFN1814-6B DFN1814-6B (⇒ wiring A) (		Symbol	Description				
DFN1814-6B			,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	2 3 3 3 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4				
6	6	1	V-	Pin for charger negative input				
5	5	5	VDD	Power supply pin, the substrate voltage level of the IC				
2	1	2	COUT	Output of over-charge detection, CMOS output				
3	3	3	DOUT	Output of over-discharge detection, CMOS output				
1	2	6	NC	No Connection pin				
4	4	4	VSS	VSS pin. Ground pin for the IC				

# **ABSOLUTE MAXIMUM RATINGS**

Symbol	Parameter	Rating	Unit
$V_{DD}$	Input Voltage	-0.3 to 12.0	V
V-	V- pin Input Voltage	$V_{DD}$ -30 to $V_{DD}$ +0.3	V
Vcout	COUT pin Output Voltage	$V_{DD}$ -30 to $V_{DD}$ +0.3	V
V <sub>DOUT</sub>	DOUT pin Output Voltage	Vss-0.3 to V <sub>DD</sub> +0.3	V
В	Power Dissipation (DFN1414-6B)	150	~\^/
$P_{D}$	Power Dissipation (DFN1814-6B)	-0.3 to 12.0 V  VDD-30 to VDD+0.3 V  VDD-30 to VDD+0.3 V  VSS-0.3 to VDD+0.3 V  VSS-0.3 to VDD+0.3 V  I-6B) 150 mW  -40 to 125 °C	IIIVV
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 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

Symbol	Parameter	Rating	Unit
$V_{DD1}$	Operating Voltage	1.5 to 5.0	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 ratings 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**

**R5487LxxxKD Electrical Characteristics** 

Unless otherwise provided, Ta=25°C

N340/L	XXXVD Electrical Chara	aciensues		uniess	ornerwis	rwise provided, 1a=2				
Symbol	Parameter	Cond	itions	Min.	Тур.	Max.	Unit	Circuit (1)		
Vst	Minimum Operating Voltage for 0V Charging	Voltage Define VDD-Vss = 0V	ed as V <sub>DD</sub> -V-,			1.8	V	Α		
V <sub>DET1</sub>	Over-charge Threshold	R1=330Ω	V <sub>DET1</sub> -0.020	\/	V <sub>DET1</sub> +0.020	V	В			
V DE I1	Voltage	R1 = 330Ω, -20°C ≤ Ta ≤ 6	60°C <sup>(2)</sup>	V <sub>DET1</sub> -0.025	V <sub>DET1</sub>	V <sub>DET1</sub> +0.025	V			
V <sub>REL1</sub>	Released voltage from Over-charge	R1 = 330Ω		V <sub>REL1</sub> -0.05	V <sub>REL1</sub>	V <sub>REL1</sub> +0.05	V	В		
tvDET1	Output Delay of Over-charge	$V_{DD} = 3.6V \rightarrow$	4.65V	0.7	1.0	1.3	S	В		
t <sub>VREL1</sub>	Release Delay for VD1	$V_{DD} = 4.65 V -$	→ 3.6V	11	16	21	ms	С		
V <sub>DET2</sub>	Over-discharge Threshold	Detect falling voltage	Detect falling edge of supply		V <sub>DET2</sub>	V <sub>DET2</sub> +0.035	V	D		
V <sub>REL2</sub>	Released Voltage from Over-discharge	Detect rising e voltage	V <sub>REL2</sub> ×0.975	V <sub>REL2</sub>	V <sub>REL2</sub> ×1.025	V	М			
Output Delay of		$V_{DET2} \ge 2.1V$ , $V_{DD} = 3.6V \rightarrow 2.0V$		14	20	26	ms	D		
	Over-discharge	$V_{DET2} < 2.1V,$ $V_{DD} = 3.6V \rightarrow 1.9V$		14	20	26	ms			
tvrel2	Release Delay for VD2	$V_{DET2} \ge 2.1V$ , $V_{DD} = 2.0V \rightarrow 3.6V$		0.7	1.2	1.7	ms	Е		
tvrel2	Release Delay for VD2	$V_{DET2} < 2.1V$ , $V_{DD} = 1.9V \rightarrow$	3.6V	0.7	1.2	1.7	ms			
		Detect rising	V <sub>DET3</sub> ≤ 0.05V	V <sub>DET3</sub> -0.005		V <sub>DET3</sub> +0.005	V			
$V_{DET3}$	Excess discharge-current threshold	edge of 'V-' pin voltage,	0.05V < V <sub>DET3</sub> < 0.1V	V <sub>DET3</sub> <b>×</b> 0.9	V <sub>DET3</sub>	V <sub>DET3</sub> ×1.1	V	F		
		VDD = 3.1V	V <sub>DET3</sub> ≥ 0.1V	V <sub>DET3</sub> -0.010		V <sub>DET3</sub> +0.010	ms ms ms V			
tvdet3	Output delay of excess discharge-current	$V_{DD} = 3.1V, V - V_{SHORT} \times 0.77 - V_{SHORT} \times$		8	12	16	ms	F		
t <sub>VREL3</sub>	Output delay of release from excess discharge-current	$V_{DD} = 3.1V, V_{-} = 3.1V \rightarrow 0V$		0.7	1.2	1.7	ms	F		
V <sub>SHORT</sub>	Short Protection Voltage	V <sub>DD</sub> = 3.1V		V <sub>SHORT</sub> ×0.75	V <sub>SHORT</sub>	V <sub>SHORT</sub> <b>x1.25</b>	V	F		
tshort	Delay Time for Short Protection	V <sub>DD</sub> = 3.1V, V-	· = 0V → 0.5V	180	250	425	μs	F		
R <sub>SHORT</sub>	Reset Resistance for Excess Current Protection	$V_{DD} = 3.6V, V-$	= 1.0V	14	20.5	27	kΩ	F		

<sup>(1)</sup> Refer to TEST CIRCUITS for details.

<sup>&</sup>lt;sup>(2)</sup> 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.

NO. EA-357-191125

R5487LxxxKD Electrical Characteristics (Continued) Unless otherwise provided, Ta=25°C Circuit Unit **Symbol Parameter Conditions** Min. Тур. Max. (1) Detect  $V_{\mathsf{DET4}}$  $V_{\text{DET4}}$  $V_{DET4} > -0.05V$ V falling edge -0.005+0.005Excess charge-current of 'V-' pin G  $V_{\mathsf{DET4}}$  $V_{\mathsf{DET4}}$ Threshold  $V_{\mathsf{DET4}}$  $V_{\text{DET4}}$ voltage, V V<sub>DET4</sub> ≤ -0.05V VDD = 3.1V×1.1 x0.9 Output delay of excess  $V_{DD} = 3.1V$ ,  $V - = 0V \rightarrow -1V$ 5 8 11 G ms tvdet4 charge-current Output delay of release from excess charge- $V_{DD} = 3.1V$ ,  $V = -1V \rightarrow 0V$ 0.7 1.2 1.7 G ms t<sub>VREL4</sub> current Delay Time Shortening -2.6 -2.0 -1.4 ٧ G  $V_{\text{DS}}$  $V_{DD} = 3.6V$ Mode Voltage  $V_{\text{OL1}}$ Nch ON-Voltage of COUT  $IoI = 50 \mu A$ ,  $V_{DD} = 4.8 V$ 0.4 0.5 ٧ Н V<sub>OH1</sub> Pch ON-Voltage of COUT  $loh = -50 \mu A, V_{DD} = 3.9 V$ 3.4 3.7 ٧  $V_{DET2} \ge 2.1V$ ٧ 0.2 0.5  $IoI = 50 \mu A, V_{DD} = 2.0 V$  $V_{\text{OL2}}$ Nch ON-Voltage of DOUT J  $V_{DET2} < 2.1V$ 0.2 0.5 ٧  $IoI = 50 \mu A, V_{DD} = 1.9 V$  $V_{\text{OH2}}$ Pch ON-Voltage of DOUT  $loh = -50 \mu A, V_{DD} = 3.9 V$ 3.4 3.7 ٧ Supply Current  $V_{DD} = 3.9V, V_{-} = 0V$ 3.0 μΑ  $I_{DD}$ 6.0  $V_{DET2} \ge 2.1V, V_{DD} = 2.0V$ 0.5 μΑ Standby Current L ISTANDBY  $V_{DET2} < 2.1V, V_{DD} = 1.9V$ 0.5 μΑ

<sup>(1)</sup> Refer to TEST CIRCUITS for details.

R5487LxxxKM Electrical Characteristics	
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Unless otherwise provided, Ta=25°C

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Symbol	Parameter	Cond	itions	Min.	Тур.	Max.	Unit	Circuit (1)
Vst	Minimum Operating Voltage for 0V Charging	Voltage Define V <sub>DD</sub> -V-, V <sub>DD</sub> -Vs				1.8	V	Α
V <sub>DET1</sub>	Over-charge Threshold	R1 = 330Ω		V <sub>DET1</sub> -0.020	V <sub>DET1</sub>	V <sub>DET1</sub> +0.020	V	В
VDETT	Voltage	R1 = $330\Omega$ , -20°C ≤ Ta ≤ 6	0°C <sup>(2)</sup>	V <sub>DET1</sub> -0.025	VDETT	V <sub>DET1</sub> +0.025	V	
V <sub>REL1</sub>	Released voltage from Over-charge	R1 = 330Ω		V <sub>REL1</sub> -0.05	V <sub>REL1</sub>	V <sub>REL</sub> +0.05	V	В
tvdet1	Output Delay of Over-charge	$V_{DD} = 3.6V \rightarrow 4$	$V_{DD} = 3.6V \rightarrow 4.65V$			1.3	s	В
tvrel1	Release Delay for VD1	$V_{DD} = 4.65V \rightarrow$	$V_{DD} = 4.65V \rightarrow 3.6V$			21	ms	С
V <sub>DET2</sub>	Over-discharge Threshold	Detect falling e voltage	V <sub>DET2</sub> -0.035	V <sub>DET2</sub>	V <sub>DET2</sub> +0.035	V	D	
V <sub>REL2</sub>	Released Voltage from Over-discharge	Detect rising e voltage	V <sub>REL2</sub> ×0.975	V <sub>REL2</sub>	V <sub>REL2</sub> ×1.025	V	М	
t vocas	Output Delay of	$V_{DET2} \ge 2.1V$ , $V_{DD} = 3.6V \rightarrow 2$	2.0V	14	20	26	ms	D
tvdet2	Over-discharge	$V_{DET2} < 2.1V,$ $V_{DD} = 3.6V \rightarrow 1.9V$		14	20	26	ms	
4	Balanca Dalay for VD2	$V_{DET2} \ge 2.1V$ , $V_{DD} = 2.0V \rightarrow 3$	0.7	1.2	1.7	ms	Е	
tvrel2	Release Delay for VD2	$V_{DET2} < 2.1V$ , $V_{DD} = 1.9V \rightarrow 3$	3.6V	0.7	1.2	1.7	ms	F
		Detect rising	V <sub>DET3</sub> ≤ 0.05V	V <sub>DEТ3</sub> -0.005		V <sub>DET3</sub> +0.005	V	
$V_{DET3}$	Excess discharge- current threshold	edge of 'V-' pin voltage,	0.05V < V <sub>DET3</sub> < 0.1V	V <sub>DET3</sub> <b>×</b> 0.9	V <sub>DET3</sub>	V <sub>DEТ3</sub> <b>х</b> 1.1	V	F
		$V_{DD} = 3.1V$	V <sub>DET3</sub> ≥ 0.1V	V <sub>DET3</sub> -0.010		V <sub>DET3</sub> +0.010	ms ms V V V	
V <sub>REL3</sub>	Released Voltage from Excess discharge- current	Detect falling e	•	1.82	1.935	2.05	V	F
t <sub>VDET3</sub>	Output delay of excess discharge-current	$V_{DD} = 3.1V, V-[V_{SHORT} \times 0.77-0]$		8	12	16	ms	F
t <sub>VREL3</sub>	Output delay of release from excess discharge- current	V <sub>DD</sub> = 3.1V, V-		0.7	1.2	1.7	ms	F
V <sub>SHORT</sub>	Short Protection Voltage	V <sub>DD</sub> = 3.1V		V <sub>SHORT</sub> ×0.75	V <sub>SHORT</sub>	V <sub>SHORT</sub> ×1.25	V	F
t <sub>SHORT</sub>	Delay Time for Short Protection	V <sub>DD</sub> = 3.1V, V-	= 0V → 0.5V	180	250	425	μs	F

 $<sup>^{(1)}</sup>$  Refer to  $T\!EST$  CIRCUITS for details.

<sup>&</sup>lt;sup>(2)</sup> 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.

NO. EA-357-191125

R5487LxxxKM Electrical Characteristics (Continued) Unless otherwise provided, Ta=25°C Circuit Unit **Symbol Parameter** Conditions Min. Max. Тур. (1) Reset Resistance for F **R**SHORT  $V_{DD} = 3.6V, V_{-} = 1.0V$ 18 22 26  $k\Omega$ **Excess Current Protection** Detect  $V_{\mathsf{DET4}}$  $V_{\mathsf{DET4}}$ ٧  $V_{DET4} > -0.05V$ falling edge -0.005+0.005Excess charge-current  $V_{\mathsf{DET4}}$ of 'V-' pin  $V_{\mathsf{DET4}}$ G Threshold voltage, V<sub>DET4</sub>  $V_{\mathsf{DET4}}$ V<sub>DET4</sub> ≤ -0.05V ٧  $V_{DD} = 3.1V$ ×1.1 ×0.9 Output delay of excess  $V_{DD} = 3.1V, V_{-} = 0V \rightarrow -1V$ G 5 8 11 ms t<sub>VDET4</sub> charge-current Output delay of release  $V_{DD} = 3.1 \text{V}. \text{ V-} = -1 \text{V} \rightarrow 0 \text{V}$ from excess charge-0.7 1.2 1.7 ms G  $t_{\text{VREL4}}$ current **Delay Time Shortening**  $V_{DS}$  $V_{DD} = 3.6V$ -2.6 -2.0 -1.4 ٧ G Mode Voltage  $IoI = 50 \mu A, V_{DD} = 4.8 V$  $V_{OL1}$ Nch ON-Voltage of COUT 0.4 0.5 V Н V<sub>OH1</sub> Pch ON-Voltage of COUT  $loh = -50 \mu A, V_{DD} = 3.9 V$ 3.7 V ı 3.4  $V_{DET2} \ge 2.1V$ , 0.2 0.5 ٧  $IoI = 50 \mu A, V_{DD} = 2.0 V$  $V_{\text{OL2}}$ Nch ON-Voltage of DOUT J  $V_{DET2} < 2.1V$ 0.2 0.5 ٧  $Iol=50\mu A$ ,  $V_{DD}=1.9V$ Pch ON-Voltage of DOUT  $loh=-50\mu A, V_{DD}=3.9V$ V  $V_{\text{OH2}}$ 3.4 3.7 Κ Supply Current  $V_{DD} = 3.9V, V_{-} = 0V$ 3.0 L  $I_{DD}$ 6.0 μΑ  $V_{DET2} \ge 2.1V, V_{DD} = 2.0V$ 0.5 μΑ Standby Current L **I**STANDBY  $V_{DET2} < 2.1V, V_{DD} = 1.9V$ 0.5 μА

<sup>(1)</sup> Refer to TEST CIRCUITS for details.

## **R5497LxxxKF Electrical Characteristics**

Unless otherwise provided, Ta=25°C

K349/L	XXXNF Electrical Chara		Unless otherwise provided, 1a=25°					
Symbol	Parameter	Cond	itions	Min.	Тур.	Max.	Unit	Circuit (1)
V <sub>NOCHG</sub>	Maximum Operating Voltage for Inhibition of Charger	Voltage Definion		0.8	1.2	1.6	V	А
V <sub>DET1</sub>	Over-charge Threshold	R1 = 330Ω		V <sub>DET1</sub> -0.020	V <sub>DET1</sub>	V <sub>DET1</sub> +0.020	V	В
VDETT	Voltage	-20°C ≤ Ta ≤ 6	60°C <sup>(2)</sup>	V <sub>DET1</sub> -0.025	V DET1	V <sub>DET1</sub> +0.025	v	
V <sub>REL1</sub>	Released voltage from Over-charge	$R1 = 330\Omega$		V <sub>REL1</sub> -0.05	V <sub>REL1</sub>	V <sub>REL1</sub> +0.05	V	В
tvdet1	Output Delay of Over-charge	$V_{DD} = 3.6V \rightarrow$	4.65V	0.7	1.0	1.3	s	В
tvrel1	Release Delay for VD1	$V_{DD} = 4.65V -$	→ 3.6V	11	16	21	ms	С
V <sub>DET2</sub>	Over-discharge Threshold	Detect falling edge of supply voltage		V <sub>DET2</sub> -0.035	V <sub>DET2</sub>	V <sub>DET2</sub> +0.035	V	D
V <sub>REL2</sub>	Released Voltage from Over-discharge	Detect rising edge of supply voltage		V <sub>REL2</sub> ×0.975	V <sub>REL2</sub>	V <sub>REL2</sub> ×1.025	V	М
<b>.</b>	Output Delay of	$V_{DET2} \ge 2.1V$ , $V_{DD} = 3.6V \rightarrow$	14	20	26	ms	D	
	Over-discharge	$V_{DET2} < 2.1V$ , $V_{DD} = 3.6V \rightarrow 1.9V$		14	20	26	ms	
4	Pologo Polov for VP2	$V_{DET2} \ge 2.1V$ , $V_{DD} = 2.0V \rightarrow$	3.6V	0.7	1.2	1.7	ms	E
tvrel2	Release Delay for VD2	$V_{DET2} < 2.1V$ , $V_{DD} = 1.9V \rightarrow$	3.6V	0.7	1.2	1.7	ms	-
		Detect rising	V <sub>DET3</sub> ≤ 0.05V	V <sub>DET3</sub> -0.005		V <sub>DET3</sub> +0.005	V	
$V_{DET3}$	Excess discharge- current threshold	edge of 'V-' pin voltage.	0.05V < V <sub>DET3</sub> < 0.1V	V <sub>DET3</sub> <b>×</b> 0.9	V <sub>DET3</sub>	V <sub>DET3</sub> ×1.1	V	F
		$V_{DD} = 3.1V$	V <sub>DET3</sub> ≥ 0.1V	V <sub>DET3</sub> -0.010		V <sub>DET3</sub> +0.010	V	
tvdet3	Output delay of excess discharge-current	$V_{DD} = 3.1V, V$ [V <sub>SHORT</sub> × 0.77		8	12	16	ms	F
t <sub>VREL3</sub>	Output delay of release from excess discharge-current	V <sub>DD</sub> = 3.1V, V	- = 3.1V → 0V	0.7	1.2	1.7	ms	F
V <sub>SHORT</sub>	Short Protection Voltage	V <sub>DD</sub> = 3.1V		V <sub>SHORT</sub> <b>×</b> 0.75	V <sub>SHORT</sub>	V <sub>SHORT</sub> <b>×1.25</b>	V	F
t <sub>SHORT</sub>	Delay Time for Short Protection	V <sub>DD</sub> = 3.1V, V	- = 0V → 0.5V	180	250	425	μs	F
R <sub>SHORT</sub>	Reset Resistance for Excess Current Protection	V <sub>DD</sub> = 3.6V, V-	· = 1.0V	14	20.5	27	kΩ	F

<sup>(1)</sup> Refer to TEST CIRCUITS for details.

<sup>&</sup>lt;sup>(2)</sup> 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.

NO. EA-357-191125

R5497LxxxKF Electrical Characteristics (Continued) Unless otherwise provided, Ta=25°C Circuit Unit **Symbol Parameter Conditions** Min. Max. Тур. (1) Detect V<sub>DET4</sub>  $V_{\mathsf{DET4}}$  $V_{DET4} > -0.05V$ V falling edge -0.005+0.005Excess charge-current of 'V-' pin  $V_{\mathsf{DET4}}$ G  $V_{\mathsf{DET4}}$ Threshold  $V_{\text{DET4}}$  $V_{\text{DET4}}$ voltage, V V<sub>DET4</sub> ≤ -0.05V  $V_{DD} = 3.1V$ × 1.1  $\times 0.9$ Output delay of excess  $V_{DD} = 3.1V$ ,  $V = 0V \rightarrow -1V$ 5 G 8 11 ms tvdet4 charge-current Output delay of release from excess charge- $V_{DD} = 3.1V$ ,  $V = -1V \rightarrow 0V$ 0.7 1.2 1.7 G ms t<sub>VREL4</sub> current Delay Time Shortening ٧ G  $V_{\text{DS}} \\$  $V_{DD} = 3.6V$ -2.6 -2.0 -1.4 Mode Voltage  $V_{OL1}$ Nch ON-Voltage of COUT  $IoI = 50 \mu A, V_{DD} = 4.8 V$ 0.4 0.5 ٧ Н  $V_{\text{OH1}}$ Pch ON-Voltage of COUT  $loh = -50 \mu A, V_{DD} = 3.9 V$ 3.4 3.7 ٧ V<sub>DET2</sub> ≥ 2.1V ٧ 0.2 0.5  $IoI = 50 \mu A, V_{DD} = 2.0 V$  $V_{OL2} \\$ Nch ON-Voltage of DOUT J  $V_{DET2} < 2.1V$ 0.2 0.5 ٧  $IoI = 50 \mu A, V_{DD} = 1.9 V$  $V_{\text{OH2}}$ Pch ON-Voltage of DOUT  $loh = -50 \mu A, V_{DD} = 3.9 V$ 3.4 3.7 ٧  $V_{DD} = 3.9V, V_{-} = 0V$ Supply Current 3.0 μΑ  $I_{DD}$ 6.0  $V_{DET2} \ge 2.1V, V_{DD} = 2.0V$ 0.5 μΑ Standby Current L **I**STANDBY  $V_{DET2} < 2.1V, V_{DD} = 1.9V$ 0.5 μΑ

<sup>(1)</sup> Refer to TEST CIRCUITS for details.

# **R5487LxxxKP Electrical Characteristics**

Unless otherwise provided, Ta=25°C

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Symbol	Parameter	Cond	litions	Min.	Тур.	Max.	Unit	Circuit (1)
VNOCHG	Maximum Operating Voltage for Inhibition of Charger	Voltage Defin V <sub>DD</sub> -V <sub>SS</sub> , V <sub>DD</sub>		0.8	1.2	1.6	V	А
V <sub>DET1</sub>	Over-charge Threshold	$R1 = 330\Omega$		V <sub>DET1</sub> -0.020	V <sub>DET1</sub>	V <sub>DET1</sub> +0.020	V	В
V DETT	Voltage	-20°C ≤ Ta ≤	60°C <sup>(2)</sup>	V <sub>DET1</sub> -0.025	V DET1	V <sub>DET1</sub> +0.025	V	
V <sub>REL1</sub>	Released voltage from Over-charge			V <sub>REL1</sub> -0.05	V <sub>REL1</sub>	V <sub>REL1</sub> +0.05	V	В
tvdet1	Output Delay of Over-charge	$V_{DD} = 3.6V \rightarrow 4.65V$		0.7	1.0	1.3	s	В
tvrel1	Release Delay for VD1	$V_{DD} = 4.65V -$		11	16	21	ms	С
V <sub>DET2</sub>	Over-discharge Threshold	supply voltage		V <sub>DET2</sub> -0.035	V <sub>DET2</sub>	V <sub>DET2</sub> +0.035	V	D
V <sub>REL2</sub>	Released Voltage from Over-discharge	voltage	edge of supply	V <sub>REL2</sub> ×0.975	V <sub>REL2</sub>	V <sub>REL2</sub> ×1.025	V	М
tvdet2	Output Delay of	$V_{DET2} \ge 2.1V$ , $V_{DD} = 3.6V \rightarrow$	2.0V	14	20	26	ms	D
(VDE12	Over-discharge	$V_{DET2} < 2.1V,$ $V_{DD} = 3.6V \rightarrow 1.9V$		14	20	26	ms	
tvrel2	Release Delay for VD2	$V_{DET2} \ge 2.1V$ , $V_{DD} = 2.0V \rightarrow 3.6V$		0.7	1.2	1.7	ms	E
TVREL2	Release Delay for VD2	$V_{DET2} < 2.1V$ , $V_{DD} = 1.9V \rightarrow$	· 3.6V	0.7	1.2	1.7	ms	
		Detect	V <sub>DET3</sub> ≤ 0.05V	V <sub>DET3</sub> -0.005		V <sub>DET3</sub> +0.005	V	
$V_{DET3}$	Excess discharge-current threshold	rising edge of 'V-' pin voltage,	0.05V < V <sub>DET3</sub> < 0.1V	V <sub>DET3</sub> <b>×</b> 0.9	V <sub>DET3</sub>	V <sub>DET3</sub> ×1.1	V	F
		$V_{DD} = 3.1V$	V <sub>DET3</sub> ≥ 0.1V	V <sub>DET3</sub> -0.010		V <sub>DET3</sub> +0.010	V	
V <sub>REL3</sub>	Released Voltage from Excess discharge-current		e, $V_{DD} = 3.1V$	1.82	1.935	2.05	V	F
t <sub>VDET3</sub>	Output delay of excess discharge-current	$V_{DD} = 3.1V, V$ $[V_{SHORT} \times 0.77]$		8	12	16	ms	F
t <sub>VREL3</sub>	Output delay of release from excess discharge-current	V <sub>DD</sub> = 3.1V, V	'-=3.1V → 0V	0.7	1.2	1.7	ms	F
V <sub>SHORT</sub>	Short Protection Voltage	$V_{DD} = 3.1V$		V <sub>SHORT</sub> × 0.75	V <sub>SHORT</sub>	V <sub>SHORT</sub> × 1.25	V	F
tshort	Delay Time for Short Protection	$V_{DD} = 3.1V, V$	r-=0V → 0.5V	180	250	425	μs	F
Rshort	Reset Resistance for Excess Current Protection	V <sub>DD</sub> = 3.6V, V	-= 1.0V	18	22	26	kΩ	F

<sup>(1)</sup> Refer to TEST CIRCUITS for details.

<sup>&</sup>lt;sup>(2)</sup> 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.

NO. EA-357-191125

R5487L	xxxKP Electrical Chara	acteristics (	Continued)	Unles	s otherw	ise provid	ded, Ta	=25°C
Symbol	Parameter	Cond	litions	Min.	Тур.	Max.	Unit	Circuit (1)
\/	Excess charge-current	Detect falling edge	V <sub>DET4</sub> > -0.05V	V <sub>DET4</sub> -0.005	\/	V <sub>DET4</sub> +0.005	V	
Vdet4	Threshold	of 'V-' pin voltage, V <sub>DD</sub> = 3.1V	V <sub>DET4</sub> ≤ -0.05V	V <sub>DET4</sub> <b>x1.1</b>	VDET4	V <sub>DET4</sub> <b>×</b> 0.9	V	- G
t∨DET4	Output delay of excess charge-current	V <sub>DD</sub> = 3.1V, V	'- = 0V → -1V	5	8	11	ms	G
t <sub>VREL4</sub>	Output delay of release from excess charge-current	V <sub>DD</sub> = 3.1V, V	'- = -1V → 0V	0.7	1.2	1.7	ms	G
V <sub>DS</sub>	Delay Time Shortening Mode Voltage	$V_{DD} = 3.6V$		-2.6	-2.0	-1.4	V	G
V <sub>OL1</sub>	Nch ON-Voltage of COUT	IoI = 50μA, Vi	od = 4.8V		0.4	0.5	V	Н
V <sub>OH1</sub>	Pch ON-Voltage of COUT	$loh = -50 \mu A, $	$V_{DD} = 3.9V$	3.4	3.7		V	I
V <sub>OL2</sub>	Nch ON-Voltage of DOUT	V <sub>DET2</sub> ≥ 2.1V, IoI = 50μA, V <sub>1</sub>			0.2	0.5	V	J
V OL2	Non On-Vollage of DOOT	V <sub>DET2</sub> < 2.1V, IoI = 50μA, V <sub>1</sub>		0.2	0.5	V		
V <sub>OH2</sub>	Pch ON-Voltage of DOUT	loh = -50 $\mu$ A,	$V_{DD} = 3.9V$	3.4	3.7		V	K
I <sub>DD</sub>	Supply Current	$V_{DD} = 3.9V, V_{DD}$	- = 0V		3.0	6.0	μΑ	L
lozupsy	Standby Current	$V_{DET2} \ge 2.1V, V_{DD} = 2.0V$ $V_{DET2} < 2.1V, V_{DD} = 1.9V$				0.5	μΑ	
STANDBY	Standby Current					0.5	μA	

<sup>(1)</sup> Refer to TEST CIRCUITS for details.

R5487LxxxKQ Electrical Characteristics	Unless otherwise provided, Ta=

R5487L	487LxxxKQ Electrical Characteristics			Unless otherwise provided, Ta=25°C					
Symbol	Parameter	Conditions		Min.	Тур.	Max.	Unit	Circuit (1)	
Vst	Minimum Operating Voltage for 0V Charging	Voltage Defined as V <sub>DD</sub> -V-, V <sub>DD</sub> -V <sub>SS</sub> = 0V				1.8	V	А	
V <sub>DET1</sub>	Over-charge Threshold	$R1 = 330\Omega$		V <sub>DET1</sub> -0.020	- V <sub>DET1</sub>	V <sub>DET1</sub> +0.020	V	В	
	Voltage	-20°C ≤ Ta ≤ $60$ °C <sup>(2)</sup>		V <sub>DET1</sub> -0.025		V <sub>DET1</sub> +0.025			
t∨DET1	Output Delay of Over-charge	$V_{DD} = 3.6V \rightarrow 4.65V$		0.7	1.0	1.3	s	В	
tvrel1	Release Delay for VD1	$V_{DD} = 4.0V, V_{-} = 0V \rightarrow 0.2V$		11	16	21	ms	С	
V <sub>DET2</sub>	Over-discharge Threshold	Detect falling supply voltag	•	V <sub>DET2</sub> -0.035	V <sub>DET2</sub>	V <sub>DET2</sub> +0.035	V	D	
tvdet2	Output Delay of	$V_{DET2} \ge 2.1V$ , $V_{DD} = 3.6V \rightarrow$	14	20	26	ms	D		
TADE 12	Over-discharge	$V_{DET2} < 2.1V$ , $V_{DD} = 3.6V \rightarrow$		14	20	26	ms		
<b>4</b>	Pologo Dolov for VD2	$V_{DET2} \ge 2.1V$ , $V_{DD} = 2.0V \rightarrow 3.6V$		0.7	1.2	1.7	ms	E	
tvrel2	Release Delay for VD2	$V_{DET2}$ < 2.1V, $V_{DD}$ = 1.9V $\rightarrow$ 3.6V		0.7	1.2	1.7	ms		
		Detect	V <sub>DET3</sub> ≤ 0.05V	s≤ 0.05V V <sub>DET3</sub> V <sub>DET3</sub> +0.005	V				
$V_{DET3}$	Excess discharge-current threshold	rising edge of 'V-' pin	0.05V < V <sub>DET3</sub> < 0.1V	V <sub>DET3</sub> × 0.9	V <sub>DET3</sub>	V <sub>DET3</sub> × 1.1	V	F	
		voltage, $V_{DD} = 3.1V$	V <sub>DET3</sub> ≥ 0.1V	V <sub>DET3</sub> -0.010		V <sub>DET3</sub> +0.010	V		
V <sub>REL3</sub>	Released Voltage from Excess discharge-current	Detect falling 'V-' pin voltag VDD = 3.1V	e,	1.82	1.935	2.05	V	F	
t <sub>VDET3</sub>	Output delay of excess discharge-current	$V_{DD} = 3.1V$ , $V_{SHORT} \times 0.7$		8	12	16	ms	F	
tvrel3	Output delay of release from excess discharge-current	$V_{DD} = 3.1V, V - = 3.1V \rightarrow 0V$		0.7	1.2	1.7	ms	F	
V <sub>SHORT</sub>	Short Protection Voltage	V <sub>DD</sub> = 3.1V		V <sub>SHORT</sub> × 0.75	V <sub>SHORT</sub>	V <sub>SHORT</sub> × 1.25	V	F	
t <sub>SHORT</sub>	Delay Time for Short Protection	$V_{DD} = 3.1V, V_{DD}$	/- = 0V → 0.5V	180	250	425	μs	F	
R <sub>SHORT</sub>	Reset Resistance for Excess Current Protection	V <sub>DD</sub> = 3.6V, V	′- = 1.0V	18	22	26	kΩ	F	

 $<sup>^{(1)}</sup>$  Refer to  $T\!EST$  CIRCUITS for details.

<sup>&</sup>lt;sup>(2)</sup> 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.

NO. EA-357-191125

R5487LxxxKQ Electrical Characteristics (Continued) Unless otherwise provided, Ta=25°C Circuit **Symbol Conditions** Unit **Parameter** Min. Typ. Max. (1) Detect  $V_{\mathsf{DET4}}$  $V_{DET4}$  $V_{DET4} > -0.05V$ ٧ falling edge -0.005+0.005Excess charge-current of 'V-' pin G  $V_{\mathsf{DET4}}$  $V_{\mathsf{DET4}}$ Threshold  $V_{\mathsf{DET4}}$  $V_{\mathsf{DET4}}$ voltage, V<sub>DET4</sub> ≤ -0.05V ٧ ×1.1 ×0.9  $V_{DD} = 3.1V$ Output delay of excess  $V_{DD} = 3.1V$ ,  $V = 0V \rightarrow -1V$ 5 8 G 11 tvdet4 ms charge-current Output delay of release from excess charge- $V_{DD} = 3.1V, V_{-} = -1V \rightarrow 0V$ 0.7 G 1.2 1.7 tvrel4 ms current **Delay Time Shortening** ٧ G  $V_{\text{DS}}$  $V_{DD} = 3.6V$ -2.6 -2.0 -1.4 Mode Voltage Nch ON-Voltage of COUT  $IoI = 50 \mu A$ ,  $V_{DD} = 4.8 V$  $V_{OL1}$ V Η 0.4 0.5  $V_{\text{OH1}}$ Pch ON-Voltage of COUT  $loh = -50 \mu A, V_{DD} = 3.9 V$ ٧ I 3.4 3.7  $V_{DET2} \ge 2.1V$ , ٧ 0.2 0.5  $IoI = 50 \mu A, V_{DD} = 2.0 V$  $V_{\text{OL2}} \\$ Nch ON-Voltage of DOUT J  $V_{DET2} < 2.1V$ , ٧ 0.2 0.5  $IoI = 50 \mu A$ ,  $V_{DD} = 1.9 V$  $\overline{V}_{OH2}$ Pch ON-Voltage of DOUT Ioh =  $-50\mu A$ ,  $V_{DD} = 3.9V$ ٧ 3.4 3.7 Supply Current  $V_{DD} = 3.9V, V = 0V$ 3.0 6.0 μΑ  $I_{DD}$  $V_{DET2} \ge 2.1V, V_{DD} = 2.0V$ μĀ 0.1 Standby Current ISTANDBY  $V_{DET2} < 2.1V, V_{DD} = 1.9V$ μΑ 0.1

<sup>(1)</sup> Refer to TEST CIRCUITS for details.

## **R5487LxxxSD Electrical Characteristics**

Unless otherwise provided, Ta=25°C

N3401 L	AAASD LIECTIICAI CIIAI	oniess otherwise provided, 1a=25°C						
Symbol	Parameter	Conditions		Min.	Тур.	Max.	Unit	Circuit (1)
Vst	Minimum Operating Voltage for 0V Charging	Voltage Defir				1.8	V	Α
V <sub>DET1</sub>	Over-charge Threshold	$R1 = 330\Omega$		V <sub>DET1</sub> -0.020	V <sub>DET1</sub>	V <sub>DET1</sub> +0.020	V	В
V DETT	Voltage	R1 = 330Ω, -20°C ≤ Ta ≤	60°C <sup>(2)</sup>	V <sub>DET1</sub> -0.025	V DE I 1	V <sub>DET1</sub> +0.025	V	
V <sub>REL1</sub>	Released voltage from Over-charge	R1 = 330Ω		V <sub>REL1</sub> -0.05	V <sub>REL1</sub>	V <sub>REL1</sub> +0.05	V	В
tvDET1	Output Delay of Over-charge	V <sub>DD</sub> = 3.6 V -	→ 4.65 V	0.7	1.0	1.3	S	В
t <sub>VREL1</sub>	Release Delay for VD1	$V_{DD} = 4.65 \text{ V}$	→ 3.6 V	11	16	21	ms	С
$V_{DET2}$	Over-discharge Threshold	Detect falling supply voltage		V <sub>DET2</sub> -0.035	V <sub>DET2</sub>	V <sub>DET2</sub> +0.035	V	D
V <sub>REL2</sub>	Released Voltage from Over-discharge	Detect rising edge of V <sub>REL2</sub> V <sub>PSL0</sub>		V <sub>REL2</sub> × 1.025	V	М		
t	Output Delay of Over-	$V_{DET2} \ge 2.1 V$ , $V_{DD} = 3.6 V$ -	→ 2.0 V	14	20	26	ms	D
t <sub>VDET2</sub>	discharge	V <sub>DETO</sub> < 2.1V	20	26	ms			
tvrel2	Release Delay for VD2	$V_{DET2} \ge 2.1 V$ , $V_{DD} = 2.0 V$ -	→ 3.6 V	0.7	1.2	1.7	ms	E
WREL2	Nelease Delay IOI VD2	$V_{DET2} < 2.1V$ , $V_{DD} = 1.9 V$ –		0.7	1.2	1.7	ms	
		Detect	V <sub>DET3</sub> ≤ 0.05 V	V <sub>DET3</sub> -0.005		V <sub>DET3</sub> +0.005	V	
$V_{DET3}$	Excess discharge-current threshold	rising edge of 'V-' pin voltage,	0.05 V < V <sub>DET3</sub> < 0.1 V	V <sub>DET3</sub> × 0.9	V <sub>DET3</sub>	V <sub>DET3</sub> × 1.1	V	F
		$V_{DD} = 3.1V$	V <sub>DET3</sub> ≥ 0.1 V	V <sub>DET3</sub> -0.010		V <sub>DET3</sub> +0.010	V	
tvdet3	Output delay of excess discharge-current	$V_{DD} = 3.1V, V_{SHORT} \times 0.7$		85	128	171	ms	F
tvrel3	Output delay of release from excess discharge- current			ms	F			
Vshort	Short Protection Voltage	$V_{DD} = 3.1 \text{ V}$		V <sub>SHORT</sub> × 0.75	V <sub>SHORT</sub>	V <sub>SHORT</sub> × 1.25	V	F
tshort	Delay Time for Short Protection	V <sub>DD</sub> = 3.1 V,	V- = 0V → 0.5V	180	250	425	μs	F
Rshort	Reset Resistance for Excess Current Protection	V <sub>DD</sub> = 3.6V, V	/- = 1.0V	14	20.5	27	kΩ	F

<sup>(1)</sup> Refer to TEST CIRCUITS for details.

<sup>&</sup>lt;sup>(2)</sup> 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.

NO. EA-357-191125

R5487LxxxSD Electrical Characteristics (Continued) Unless otherwise provided, Ta=25°C Circuit Unit Symbol **Parameter Conditions** Min. Max. Тур. (1) Detect V<sub>DET4</sub>  $V_{\mathsf{DET4}}$ ٧  $V_{DET4} > -0.05V$ falling edge -0.005 +0.005Excess charge-current of 'V-' pin G  $V_{\text{DET4}}$  $V_{\mathsf{DET4}}$ Threshold  $V_{\mathsf{DET4}}$  $V_{\mathsf{DET4}}$ voltage, V  $V_{DET4} \le -0.05V$ × 0.9 × 1.1  $V_{DD} = 3.1V$ Output delay of excess 17 G  $V_{DD} = 3.1 \text{ V}, \text{ V} - = 0 \text{V} \rightarrow -1 \text{V}$ 12 22 ms tvdet4 charge-current Output delay of release 0.7 1.2 1.7  $V_{DD} = 3.1 \text{ V}, \text{ V-} = -1 \text{V} \rightarrow 0 \text{V}$ G tvrel4 from excess chargems current **Delay Time Shortening** -1.4  $V_{\text{DS}}$  $V_{DD} = 3.6 \text{ V}$ -2.6 -2.0 ٧ G Mode Voltage Nch ON-Voltage of COUT V<sub>OL1</sub>  $IoI = 50\mu A, V_{DD} = 4.8 \text{ V}$ 0.4 ٧ 0.5 Н Pch ON-Voltage of COUT Ioh =  $-50\mu A$ ,  $V_{DD} = 3.9 V$ ٧  $V_{OH1}$ 3.4 3.7 1  $V_{DET2} \ge 2.1V$ 0.2 0.5 ٧  $IoI = 50\mu A$ ,  $V_{DD} = 2.0 V$  $V_{\text{OL2}}$ Nch ON-Voltage of DOUT J  $V_{DET2} < 2.1V$ 0.2 0.5 ٧  $IoI = 50\mu A$ ,  $V_{DD} = 1.9 V$ Pch ON-Voltage of DOUT  $loh = -50 \mu A, V_{DD} = 3.9 V$ ٧ 3.4 3.7 Κ  $V_{\text{OH2}}$  $V_{DD} = 3.9 \text{ V}, V_{-} = 0 \text{ V}$  $I_{DD}$ Supply Current 3.0 6.0 μΑ L  $V_{DET2} \ge 2.1 V, V_{DD} = 2.0 V$ 0.5 μΑ Standby Current L **I**STANDBY  $V_{DET2} < 2.1V, V_{DD} = 1.9 V$ μĀ 0.5

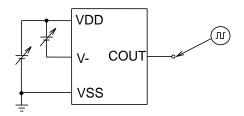
<sup>(1)</sup> Refer to TEST CIRCUITS for details.

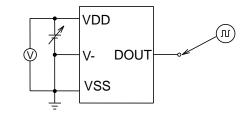
# **Test Circuits**

A VDD DOUT V- COUT OSCILLOSCOPE

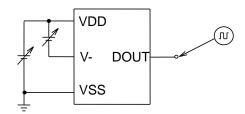
V- COUT VSS

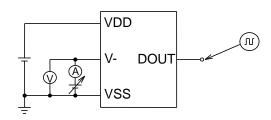
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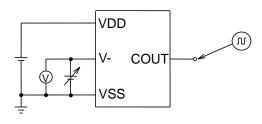


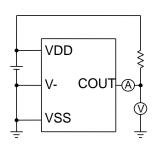
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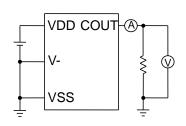


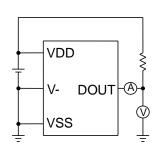
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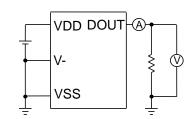
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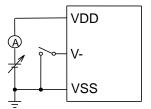
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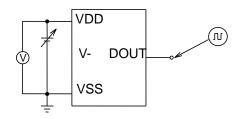
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М



## THEORY OF OPERATION

#### **VD1 / Over-Charge Detector**

The VD1 monitors V<sub>DD</sub> pin voltage while charge the battery pack. When the V<sub>DD</sub> voltage crosses over-charge detector threshold V<sub>DET1</sub> from a low value to a value higher than the V<sub>DET1</sub>, the VD1 can detect over-charge and an external charge control Nch MOSFET turn off with C<sub>OUT</sub> pin being at "L" level.

In terms of "Latch type" version, to reset the VD1 making the Cout pin level to "H" again after detecting overcharge, in such conditions that a time when the VDD voltage is down to a level lower than over-charge voltage, by disconnecting a charger from the battery pack. Output voltage of Cout pin becomes "H", and it makes an external Nch MOSFET turn on, and charge cycle is available.

Depending on the external characteristics of external components such as FETs, just by disconnecting a charger, over-charge state may not be released. In such a case, by connecting some load, the over-charge state is released. In other words, once over-charge is detected, even if the supply voltage becomes low enough, if a charger is continuously connected to the battery pack, recharge is not possible. Therefore this over-charge detector has no hysteresis. To judge whether or not load is connected, the built-in excess-discharge current detector is used. In other words, by connecting some load, V- pin voltage becomes equal or more than excess-discharge current detector threshold, and reset the over-charge detecting state.

In terms of "Auto Release type" version, after detecting over-charge, if  $V_{DD}$  pin voltage is equal or lower than the released voltage from over-charge, even if a charger is connected, over-charge detector is released. Further, in case that  $V_{DD}$  pin level is lower than the over-charge detector threshold, if a charger is removed, over-charge detector is also released. Depending on the characteristics of external components such as FETs, just by disconnecting a charger, over-charge detector may not be released, and in this case, by connecting some load, the over-charge state is released.

After detecting over-charge with the  $V_{DD}$  voltage of higher than  $V_{DET1}$ , connecting system load to the battery pack makes load current allowable through parasitic diode of external charge control FET.

The Cout level would be "H" when the VDD level is down to a level below the VDET1 by continuous drawing of load current.

Internal fixed output delay times for over-charge detection and release from over-charge exist. Even when the V<sub>DD</sub> pin level becomes equal or higher level than V<sub>DET1</sub> if the V<sub>DD</sub> voltage would be back to a level lower than the V<sub>DET1</sub> within a time period of the output delay time, VD1 would not output a signal for turning off the charge control FET. Besides, after detecting over-charge, while the V<sub>DD</sub> is lower than over-charge detector, 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.

#### **VD2 / Over-Discharge Detector**

The VD2 is monitoring a  $V_{DD}$  pin voltage. When the  $V_{DD}$  voltage crosses the over-discharge detector threshold  $V_{DET2}$  from a high value to a value lower than the  $V_{DET2}$ , the VD2 can detect an over-discharge and the external discharge control Nch MOSFET turns off with the  $D_{OUT}$  pin being at "L" level.

In terms of "Latch type" version, to reset the VD2 with the Dout pin level being "H" again after detecting over discharge, it is necessary to connect a charger to the battery pack. When the VDD voltage stays under over-discharge detector threshold VDET2, charge-current can flow through parasitic diode of an external discharge control MOSFET, then after the VDD voltage comes up to a value larger than VDET2, then, DOUT becomes "H" and discharging process would be able to advance through ON state MOSFET for discharge control.





Connecting a charger to the battery pack makes the Dout level being "H" instantaneously when the VDD voltage is higher than VDET2.

In terms of "Auto Release type" version, released operation by connecting a charger is same as the other latch type. However, without a charger, if  $V_{DD}$  pin voltage is equal or more than the released voltage from over-discharge,  $D_{OUT}$  pin becomes "H" immediately.

When a cell voltage equals to zero, "acceptable type" version: if the voltage of a charger is equal or more than 0V-charge minimum voltage limit (Vst), Cout pin becomes "H" and a system is allowable to charge.

"Unacceptable type" version: if VDD voltage is less than charger inhibit maximum voltage (Vnochg), even if a charger is connected, COUT level will be fixed at "L", and charge current will be cut off.

An output delay time for over-discharge detection is fixed internally. When the  $V_{DD}$  level is down to equal or lower level than  $V_{DET2}$  if the  $V_{DD}$  voltage would be back to a level higher than the  $V_{DET2}$  within a time period of the output delay time, VD2 would not output a signal for turning off the discharge control FET. Output delay time for release from over-discharge is also set.

After detecting over-discharge by VD2, "Latch type" version: supply current would be reduced and be into standby by halting unnecessary circuits and consumption current of IC itself is made as small as possible. (Max.  $0.1\mu$ A at  $V_{DD}=2.0V$ )

"Auto Release type" version: supply current would be reduced and be into standby by halting circuits except the over-discharge released by voltage function. (Max.  $0.5\mu$ A at  $V_{DD}=2.0V$ )

The output type of Dout pin is CMOS having "H" level of VDD and "L" level of VSS.

## VD3 /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 Vshort and excess discharge-current threshold VDET3, VD3 operates and further soaring of V- pin voltage higher than Vshort makes the short circuit protector enabled. This leads the external discharge control Nch MOSFET turns off with the Dout 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 Vshort and VDET3 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 DouT would be "L" and the delay time to release (Typ. 1.2ms) is also set.

The V- pin has a built-in pull-down resistor (Rshort) to the Vss 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 Vss level through 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<sub>DD</sub> voltage would be lower than V<sub>DET2</sub> at the same time as the excess discharge-current is detected, the R5487 are at excess discharge-current detection mode. By disconnecting a load, VD3 is automatically released from excess discharge-current.

#### VD4 /Excess charge-current detector

When the battery pack is chargeable and discharge is also possible, VD4 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 Cout 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 VD4 threshold within the delay time, and the excess charge current is not detected. Output delay for the release from excess charge current (Typ. 1.2ms) is also set.

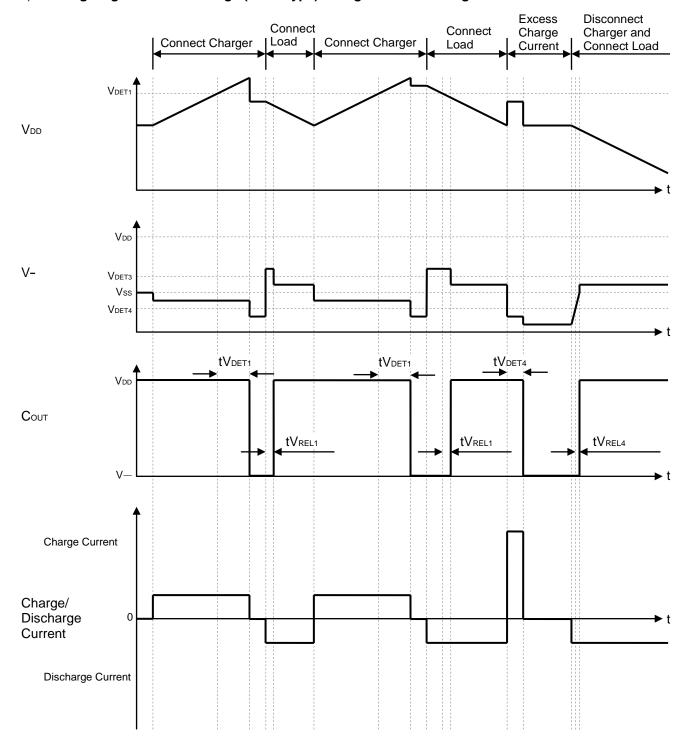
VD4 can be released with disconnecting a charger and connecting a load.

#### **DS (Delay Shorten) function**

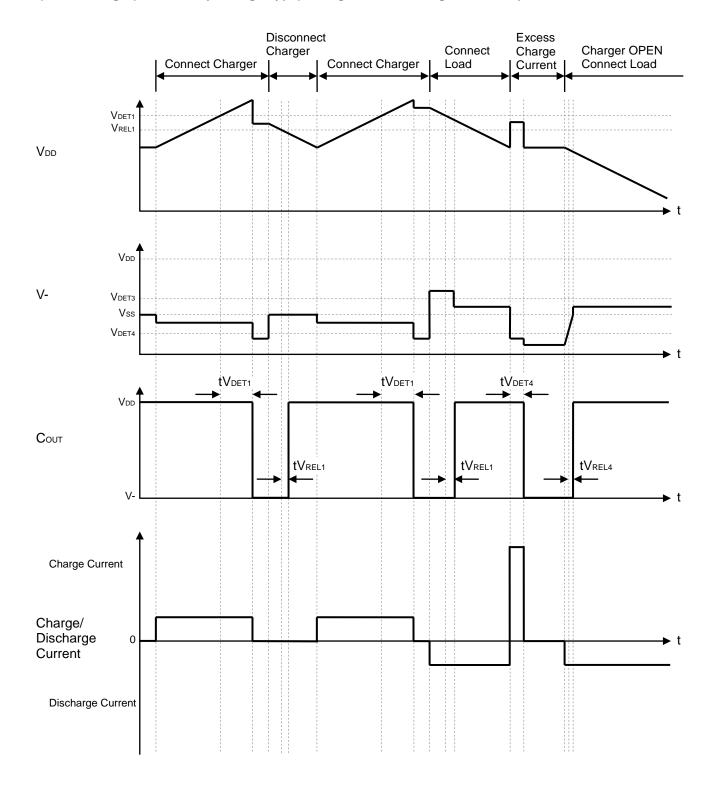
Output delay time of over-charge and over-discharge can be shorter than those setting value by forcing equal or less than the delay shortening mode voltage (Typ. -2.0V) to V- pin.

## **TIMING CHART**

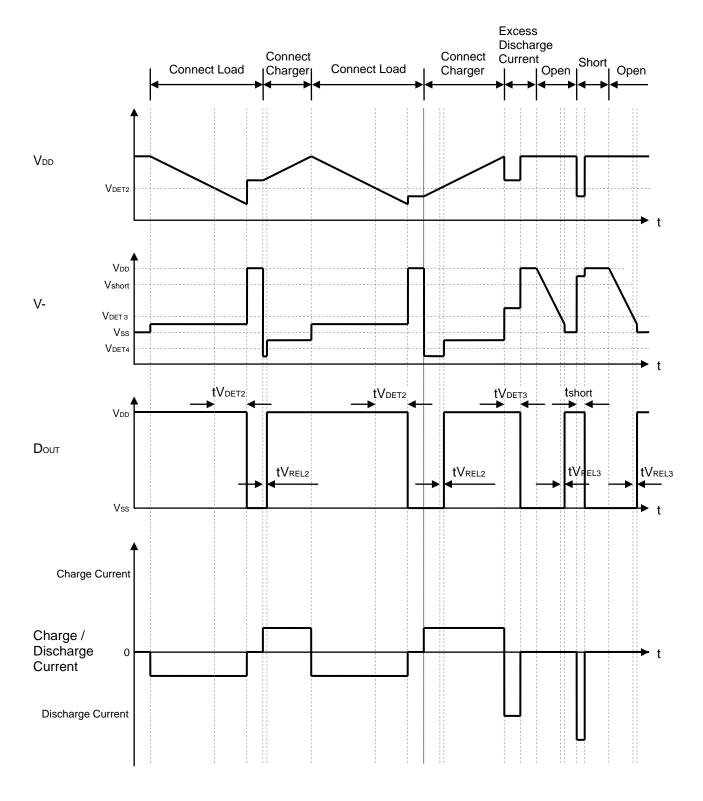
# 5) Timing diagram of over-charge (Latch type) voltage and over-charge current



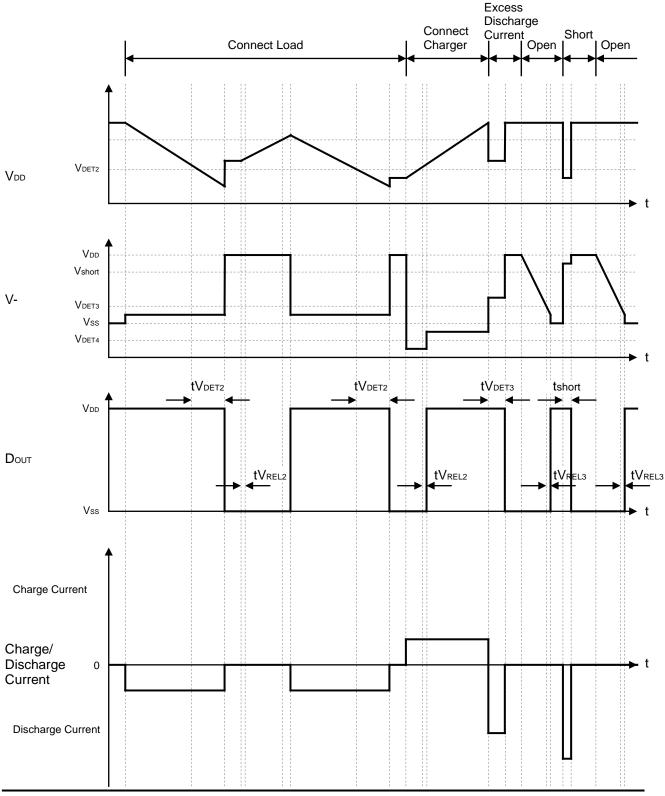
## 2) Over-charge (Released by voltage Type) voltage, Excess charge current Operation



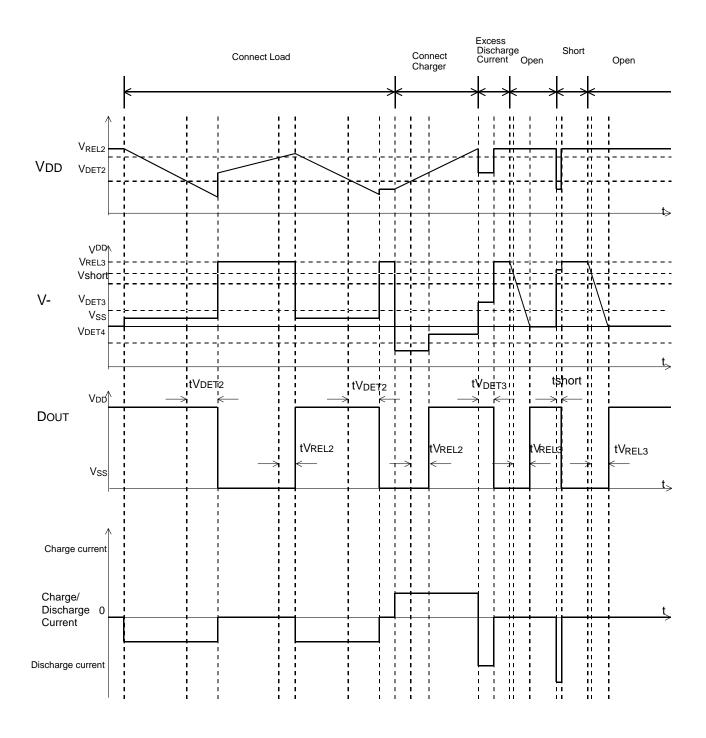
## 3) Over-discharge (Latch Type), Excess discharge current, Short circuit



# 4) Over-discharge (Released by Voltage Type), Excess discharge current (Auto-Release Type 1), Short circuit

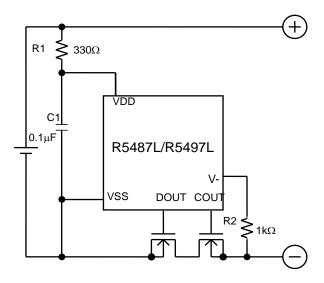


# 5) Over-discharge (Released by Voltage Type), Excess discharge current (Auto Release Type 2), Short circuit



#### APPLICATION INFORMATION

#### **Typical Application Circuit**



R1 and C1 stabilize a supply voltage to the R5487L/R5497L. A recommended R1 value is equal or less than  $1k\Omega$ . A large value of R1 makes detection voltage shift higher because of the conduction current—flowed in the R5487L/R5497L. Further, to stabilize the operation of the R5487L/R5497L, use the C1 with the value in the range from 0.01Uf to 0.1Uf. To choose the most suitable value of C1, fully evaluation is necessary.

R1 and R2 can operate also as parts for current limit circuit against reverse charge or applying a charger with excess charging voltage to the R5487, battery pack. While small value of R1 and R2 may cause over power dissipation rating of the R5487L/R5497L, therefore a total of "R1+R2" should be  $1k\Omega$  or more. Besides, if a large value of R2 is set, release from over-discharge by connecting a charger might not be possible.

In the case of "R5487L/R5497Lxxx\$M", "R5487L/R5497Lxxx\$Q", "R5487L/R5497Lxxx\$P", k", recommended R2 value is equal or less than  $1k\Omega$ . The recommended R2 value is  $1K\omega$ . In the case of

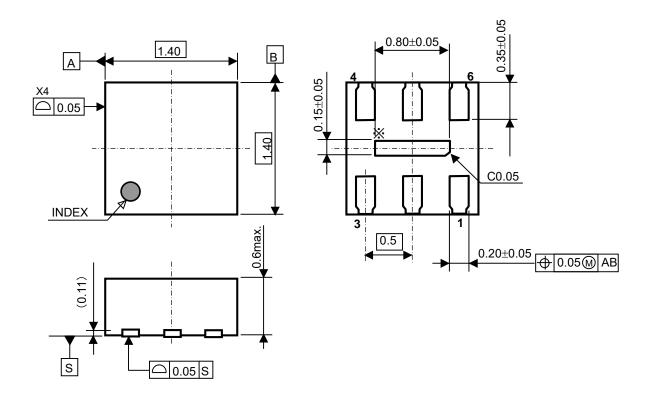
"R5487L/R5497Lxxx\$D" and "R5487L/R5497Lxxx\$F", recommended R2 value is equal or less than  $10k\Omega$ . The recommended R2 value is  $10K\omega$ .

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. If the positive terminal and the negative terminal of the battery pack are short, even though the short protection circuit is built in the IC, during the delay time until detecting the short circuit, a large current may flow through the FET. Select an FET with large enough current capacity in order to endure the large current during the delay time.

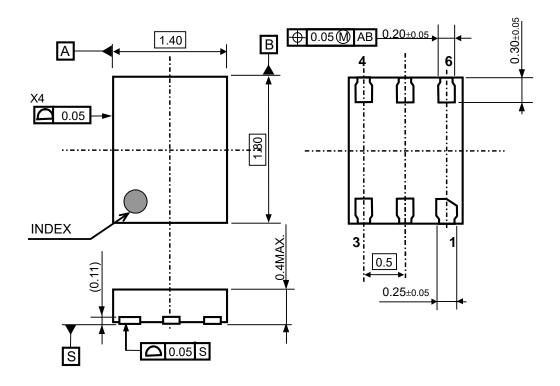
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Ver. A



**DFN1414-6B Package Dimensions (Unit: mm)** 

Ver. A



DFN1814-6B Package Dimensions (Unit: mm)



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