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Li-Ion/Li-Polymer 1-Cell Protector

OUTLINE

The R5486K is an overcharge protection IC for Lithium-ion (Li+)/Lithium polymer secondary battery. This device can detect over-charge, over-discharge, excess discharge and excess charge current of one-cell Li-ion (Li+)/Li-ion polymer battery. The external resistor added to the RSENS pin can enhance a high precision overcurrent detection. The excess discharge current detection has two stages of detections to ensure the detection accuracy. The current consumption after the over-discharge detection is suppressed by stopping the internal circuits.

FEATURES

- Absolute Maximum Rating .... 30 V
- Supply Current (Normal Mode) .... Typ. 4.0 μA
- Supply Current (Standby Mode) .... Max. 0.1 μA

Detector Thresholds Accuracy

- Over-charge Detector Threshold .... ±20 mV
- Over-discharge Detector Threshold.. ±35 mV
- Excess Discharge Current Threshold 1 (V_{DET31}) .... ±8% (V_{DET31} ≥ 0.038 V)

  ±3.1 mV (V_{DET31} < 0.038 V) [Note1]
- Excess Discharge Current Threshold 2 (V_{DET32}) .... ±8% (V_{DET32} ≥ 0.038 V)

  ±3.1 mV (V_{DET32} < 0.038 V) [Note2]
- Short Detector Threshold.. ±45 mV
- Excess Charge Current Threshold.. ±15% (V_{DET4} ≤ −0.02 V)

  ±3 mV (V_{DET4} > −0.02 V) [Note3]

[Note1]

V_{DET31} Setting Range	Accuracy
0.015 V to 0.037 V	±3.1 mV Equivalent Range: ±8.4% (V_{DET31} = 0.037 V) to ±20.6% (V_{DET31} = 0.015 V)

[Note2]

V_{DET32} Setting Range	Accuracy
0.025 V to 0.037 V	±3.1 mV Equivalent Range: ±8.4% (V_{DET32} = 0.037 V) to ±12.4% (V_{DET32} = 0.025 V)

[Note3]

V_{DET4} Setting Range	Accuracy
−0.019 V to −0.015 V	±3.0 mV Equivalent Range: ±15.8% (V_{DET4} = −0.019 V) to ±20% (V_{DET4} = −0.015 V)

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Detector Thresholds Range

- Over-charge Detector Threshold ....4.1 V to 4.5 V, 0.005 V step
- Over-discharge Detector Threshold...2.1 V to 3.0 V, 0.050 V step
- Short Detector Threshold..0.15 V −0.30 V, 0.01 V step
- Excess Charge Current Threshold..−0.060 V to −0.015 V, 0.001 V step
- Maximum Operating Voltage for Inhibition of Charger...................... 0.7 V or 1.5 V

Detector Thresholds Range (R5486KxxxCG)

- Excess Discharge Current Threshold 1 (V_{DET31}) ....0.015 V to 0.046 V, 0.001 V step
- Excess Discharge Current Threshold 2 (V_{DET32}) ....0.030 V to 0.080 V, 0.001 V step [Note4]

(Note4)

V_{DET31} Setting Range	V_{DET32} Setting Range
$V_{DET31} \leq 0.030$ V	$V_{DET32} \geq V_{DET31} + 0.015$ V
0.031 V $\leq V_{DET31} \leq 0.035$	$V_{DET32} \geq 0.051$ V
$V_{DET31} \geq 0.036$ V	$V_{DET32} \geq V_{DET31} + 0.015$ V

Detector Thresholds Range (R5486KxxxCM)

- Excess Discharge Current Threshold 1 (V_{DET31}) ....disable
- Excess Discharge Current Threshold 2 (V_{DET32}) ....0.025 V to 0.080 V, 0.001 V step

Output Delay Time

- Over-charge Detector Output Delay (t_{VDET1})……………………………1.0 s
- Over-discharge Detector Output Delay (t_{VDET2})………………………...20 ms
- Excess Discharge Current Detector Output Delay 2 (t_{VDET32})………...12 ms
- Excess Charge Current Detector Output Delay (t_{VDET4})……………….16 ms
- Short Detector Output Delay (t_{SHORT})………………………………….250 µs

Output Delay Time (R5486KxxxCG)

- Excess Discharge Current Detector Output Delay 1…………………...selectable from 3 s, 4 s or 5 s

Functions

- 0-V Battery Charge Option……………………………………………...unacceptable
- Output Delay Time Shorting Function…………………………………….At COUT is "H", if V− level is set at −2.0 V, the output Delay time of detect the over-charge and over-discharge can be reduced. (Delay Time for over-charge becomes about 1/100 of normal state.)
- Release Over-charge Detector……………………………………………Latch-type
- Release Over-discharge Detector………………………………………Latch-type
- Package……………………………………………………………………DFN(PLP)1414-6

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APPLICATIONS

- Li+/Li Polymer Protector of Over-charge, Over-discharge, Excess-current for Battery Pack
- High Precision Protectors for Smartphones and Electronic Gadgets using On-board Li+/Li Polymer Battery

SELECTION GUIDE

The input threshold of over-charge, over-discharge and excess discharge current are user-selectable options.

Selection Guide

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R5486Kxxx$∗-TR	DFN(PLP)1414-6	5,000 pcs	Yes	Yes

xxx: Set Output Voltage Code

    Refer to *R5486K Code List*.

$: Delay Time Version

Version	t_{VDET1} (s)	t_{VDET2} (ms)	t_{VDET32} (ms)	t_{VDET4} (ms)	t_{SHORT} (μs)
C	1	20	12	16	250

∗: Function Version

Version	Return from Over-Charge	Return from Over-Discharge	V_{DET31}	0-V Charge
G	Latch-type	Latch-type	Enable	NG
M	Latch-type	Latch-type	Disable	NG

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NO. EA-339-181116

Product Code List

R5486KxxxCG Code List

Code	Set Output Voltage [V]							DelayTime [s]
	V_{DET1}	V_{DET2}	V_{DET31}	V_{DET32}	V_{DET4}	V_{SHORT}	V_{NOCHG}	t_{VDET31}
R5486K101CG	4.425	2.400	0.015	0.030	−0.015	0.150	1.500	5.0
R5486K102CG	4.200	2.500	0.026	0.051	−0.046	0.150	0.700	3.0
R5486K103CG	4.280	2.600	0.030	0.045	−0.025	0.150	1.500	5.0
R5486K104CG	4.425	2.600	0.030	0.045	−0.025	0.150	1.500	5.0
R5486K105CG	4.425	2.400	0.037	0.052	−0.037	0.250	1.500	3.0
R5486K106CG	4.425	2.400	0.040	0.072	−0.022	0.250	1.500	3.0
R5486K107CG	4.425	2.400	0.040	0.072	−0.022	0.180	0.700	3.0
R5486K108CG	4.390	2.800	0.026	0.051	−0.042	0.150	0.700	5.0
R5486K109CG	4.400	2.600	0.025	0.040	−0.015	0.150	1.500	3.0
R5486K110CG	4.500	2.300	0.035	0.051	−0.043	0.250	0.700	3.0
R5486K111CG	4.450	2.600	0.033	0.055	−0.030	0.250	0.700	4.0
R5486K112CG	4.400	3.000	0.025	0.040	−0.015	0.150	1.500	3.0
R5486K113CG	4.275	2.350	0.030	0.045	−0.020	0.150	0.700	5.0
R5486K114CG	4.425	2.400	0.037	0.052	−0.033	0.250	1.500	3.0
R5486K115CG	4.280	2.900	0.030	0.045	−0.025	0.150	1.500	5.0
R5486K116CG	4.475	2.600	0.035	0.051	−0.031	0.150	0.700	3.0
R5486K117CG	4.230	2.900	0.015	0.030	−0.015	0.150	1.500	3.0
R5486K118CG	4.250	2.900	0.015	0.030	−0.015	0.150	1.500	3.0
R5486K119CG	4.470	2.300	0.037	0.054	−0.021	0.150	0.700	5.0
R5486K120CG	4.275	2.900	0.030	0.045	−0.020	0.150	0.700	5.0
R5486K121CG	4.275	2.800	0.030	0.045	−0.020	0.150	0.700	5.0

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R5486KxxxCM Code List

コード	Set Output Voltage [V]							DelayTime [s]
	V_{DET1}	V_{DET2}	V_{DET31}	V_{DET32}	V_{DET4}	V_{SHORT}	V_{NOCHG}	t_{VDET31}
R5486K501CM	4.425	2.400	-	0.040	−0.022	0.300	1.500	3.0
R5486K502CM	4.425	2.600	-	0.052	−0.022	0.150	1.500	3.0
R5486K503CM	4.475	2.600	-	0.040	−0.025	0.250	0.700	3.0
R5486K504CM	4.425	2.400	-	0.040	−0.025	0.180	0.700	3.0
R5486K505CM	4.425	2.800	-	0.040	−0.030	0.150	1.500	3.0
R5486K506CM	4.425	2.600	-	0.030	−0.031	0.180	1.500	3.0
R5486K507CM	4.280	2.800	-	0.040	−0.030	0.150	1.500	3.0
R5486K508CM	4.230	2.800	-	0.050	−0.030	0.150	1.500	3.0
R5486K509CM	4.425	2.800	-	0.050	−0.030	0.150	1.500	3.0
R5486K510CM	4.280	2.800	-	0.050	−0.030	0.150	1.500	3.0
R5486K511CM	4.280	2.400	-	0.033	−0.024	0.150	1.500	3.0
R5486K512CM	4.405	2.800	-	0.040	−0.030	0.150	1.500	3.0
R5486K513CM	4.405	2.400	-	0.033	−0.024	0.150	1.500	3.0
R5486K514CM	4.450	2.600	-	0.040	−0.030	0.150	1.500	3.0
R5486K515CM	4.280	2.400	-	0.040	−0.030	0.150	1.500	3.0
R5486K516CM	4.425	2.800	-	0.050	−0.055	0.250	1.500	3.0
R5486K517CM	4.425	2.800	-	0.065	−0.060	0.180	1.500	3.0
R5486K518CM	4.425	2.400	-	0.034	−0.023	0.180	0.700	3.0
R5486K519CM	4.475	2.400	-	0.040	−0.025	0.180	0.700	3.0
R5486K520CM	4.425	2.400	-	0.030	−0.060	0.180	0.700	3.0
R5486K521CM	4.420	2.500	-	0.035	−0.030	0.150	0.700	3.0
R5486K522CM	4.475	2.400	-	0.042	−0.025	0.180	0.700	3.0
R5486K523CM	4.420	2.500	-	0.028	−0.025	0.150	0.700	3.0
R5486K524CM	4.425	2.800	-	0.026	−0.026	0.150	1.500	3.0
R5486K525CM	4.475	2.800	-	0.040	−0.025	0.180	0.700	3.0
R5486K526CM	4.475	2.600	-	0.040	−0.025	0.180	0.700	3.0
R5486K527CM	4.475	2.800	-	0.025	−0.021	0.150	1.500	3.0
R5486K528CM	4.475	2.500	-	0.045	−0.035	0.150	0.700	3.0
R5486K529CM	4.475	2.500	-	0.045	−0.036	0.150	0.700	3.0
R5486K530CM	4.475	2.600	-	0.046	−0.031	0.150	0.700	3.0
R5486K531CM	4.230	2.800	-	0.035	−0.018	0.150	1.500	3.0

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R5486KxxxCM Code List (Continued)

Code	Set Output Voltage [V]							DelayTime [s]
	V_{DET1}	V_{DET2}	V_{DET31}	V_{DET32}	V_{DET4}	V_{SHORT}	V_{NOCHG}	t_{VDET31}
R5486K532CM	4.230	2.600	-	0.035	−0.018	0.150	1.500	3.0
R5486K533CM	4.230	2.800	-	0.045	−0.015	0.150	1.500	3.0
R5486K534CM	4.230	2.600	-	0.045	−0.015	0.150	1.500	3.0
R5486K536CM	4.500	2.900	-	0.025	−0.023	0.150	1.500	3.0
R5486K537CM	4.550	2.600	-	0.040	−0.040	0.180	0.700	3.0
R5486K538CM	4.550	2.600	-	0.045	−0.040	0.180	0.700	3.0

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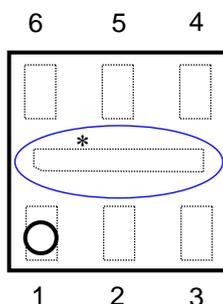
PIN DESCRIPTION

R5486K (DFN(PLP)1414-6) Pin Configuration

∗ The tab is VDD level. Do not connect other wires or lad patterns.

R5486K Pin Description

Pin No.	Symbol	Description
1	VSS	VSS pin. Ground pin for the IC
2	VDD	Power supply pin, the substrate voltage level of the IC.
3	RSENS	Input of overcurrent detection
4	V−	Pin for charger negative input
5	COUT	Output of over-charge detection, CMOS output
6	DOUT	Output of over-discharge detection, CMOS output

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ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings (Ta = 25°C, V_{SS} = 0 V)

Symbol	Parameter	Ratings	Unit
V_{DD}	Supply Voltage	−0.3 to 12	V
V−	V− Pin Input Voltage	V_{DD} −30 to V_{DD} +0.3	V
V_{RSENS}	RSENS Pin Input Voltage	V_{SS} −0.3 to V_{DD} +0.3	V
V_{COUT}	COUT Pin Output Voltage	V_{DD} −30 to V_{DD} +0.3	V
V_{DOUT}	DOUT Pin Output Voltage	V_{SS} −0.3 to V_{DD} +0.3	V
P_D	Power Dissipation	150	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 the permanent damages and may degrade the lifetime and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings is not assured.

RECOMMENDED OPERATING CONDITIONS

Recommended Operating Conditions

Symbol	Parameter	Rating	Unit
V_{DD1}	Operating Input 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 when they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

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ELECTRICAL CHARACTERISTICS

R5486K Electrical Characteristics (Ta = 25°C)

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_{NOCHG}	Maximum Operating Voltage for Inhibition of Charger	Voltage Defined as VDD–VSS, $V_{DD} - V- = 4$ V		V_{NOCHG} −0.3	V_{NOCHG}	V_{NOCHG} +0.3	V
V_{DET1}	Over-charge Threshold Voltage	R1 = 330 Ω		V_{DET1} −0.020	V_{DET1}	V_{DET1} +0.020	V
t_{VDET1}	Output Delay of Over-charge	$V_{DD} = 3.6$ V $\rightarrow V_{DET1} + 0.05$ V		0.7	1.0	1.3	s
t_{VREL1}	Release Delay for VD1	$V_{DD} = 3.9$ V, V− = 0 V $\rightarrow$ 1 V		11	16	21	ms
V_{DET2}	Over-discharge Threshold	Detect falling edge of supply voltage		V_{DET2} −0.035	V_{DET2}	V_{DET2} +0.035	V
t_{VDET2}	Output Delay of Over-discharge	$V_{DD} = V_{DET2} + 0.13$ V $\rightarrow V_{DET2} - 0.08$ V		14	20	26	ms
t_{VREL2}	Release Delay for VD2	$V_{DD} = 1.9$ V $\rightarrow V_{DET2} + 0.08$ V		0.7	1.2	1.7	ms
V_{DET31}	Excess Discharge-current Threshold	Detect rising edge of RSENS pin voltage	$V_{DET31} < 0.038$ V	V_{DET31} −0.0031	V_{DET31}	V_{DET31} +0.0031	V
			$V_{DET31} \geq 0.038$ V	V_{DET31} ×0.92	V_{DET31}	V_{DET31} ×1.08	V
t_{VDET31}	Output Delay of Excess Discharge-current 1	$V_{DD} = 3.0$ V, $V_{RSENS} = 0$ V to V_{DET31} x 1.18 V− = V_{RSENS}		t_{VDET31} ×0.7	t_{VDET31}	t_{VDET31} ×1.3	s
V_{DET32}	Excess Discharge-current Threshold	Detect rising edge of RSENS pin voltage, V− = 0 V	$V_{DET32} < 0.038$ V	V_{DET32} −0.0031	V_{DET32}	V_{DET32} +0.0031	V
			$V_{DET32} \geq 0.038$ V	V_{DET32} ×0.92	V_{DET32}	V_{DET32} ×1.08	V
t_{VDET32}	Output Delay of Excess Discharge-current 2	$V_{DD} = 3.0$ V, $V_{RSENS} = 0$ V to 0.1 V, V− = V_{RSENS}		8	12	16	ms
t_{VREL3}	Output Delay of Release from Excess Discharge-current	$V_{DD} = 3.1$ V, V− = 3.1 V to 0 V V− = V_{RSENS}		0.7	1.2	1.7	ms
V_{SHORT}	Short Protection Voltage	$V_{DD} = 3.1$ V, $V_{RSENS} = $ V−		V_{SHORT} −0.045	V_{SHORT}	V_{SHORT} +0.045	V
t_{SHORT}	Delay Time for Short Protection[1]	$V_{DD} = 3.1$ V, $V_{RSENS} = 0$ V to 3.1 V, V− = V_{RSENS}		180	250	425	μs
R_{SHORT}	Reset Resistance for Excess Current Protection	$V_{DD} = 3.6$ V, V− = 1.0 V		20	45	70	kΩ
V_{DET4}	Excess Charge-current Threshold	Detect falling edge of RSENS pin voltage, V− = 0 V	$V_{DET4} > -0.02$ V	V_{DET4} −0.003	V_{DET4}	V_{DET4} +0.003	V
			$V_{DET4} \leq -0.02$ V	V_{DET4} ×1.15	V_{DET4}	V_{DET4} ×0.85	V

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[1] Output Delay Time for Release from Short Protection is the same value as t_{VREL3}.

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R5486K Electrical Characteristics (Continued) (Ta = 25°C)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
t_{VDET4}	Output Delay of Excess Charge-current	V_{DD} = 3.1 V, V_{RSENS} = 0 V to −0.5 V, V− = V_{RSENS}	11	16	21	ms
t_{VREL4}	Output Delay of Release from Excess Charge-current	V_{DD} = 3.1 V, V− = −0.5 V to 0 V, V− = V_{RSENS}	0.7	1.2	1.7	ms
V_{DS}	Delay Time Shortening Mode Voltage	V_{DD} = 3.6 V	−2.6	−2.0	−1.4	V
V_{OL1}	Nch ON-Voltage of C_{OUT}	Iol = 50 µA, V_{DD} = 4.55 V		0.4	0.5	V
V_{OH1}	Pch ON-Voltage of C_{OUT}	Ioh = −50 µA, V_{DD} = 3.9 V	3.4	3.7		V
V_{OL2}	Nch ON-Voltage of D_{OUT}	Iol = 50 µA, V_{DD} = 1.9 V		0.2	0.5	V
V_{OH2}	Pch ON-Voltage of D_{OUT}	Ioh = −50 µA, V_{DD} = 3.9 V	3.4	3.7		V
I_{DD}	Supply Current	V_{DD} = 3.9 V, V− = 0 V		4.0	8.0	µA
Istandby	Standby Current	V_{DD} = 2.0 V			0.1	µA

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All of these specifications are guaranteed by design, not tested in mass production.

R5486K Electrical Characteristics   **(-20°C < Ta < 60°C)**

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_{NOCHG}	Maximum Operating Voltage for Inhibition of Charger	Voltage Defined as VDD–VSS, $V_{DD} - V- = 4$ V		V_{NOCHG} −0.43	V_{NOCHG}	V_{NOCHG} +0.4	V
V_{DET1}	Over-charge Threshold Voltage	R1 = 330 Ω		V_{DET1} −0.025	V_{DET1}	V_{DET1} +0.025	V
t_{VDET1}	Output Delay of Over-charge	$V_{DD} = 3.6$ V → V_{DET1} + 0.05 V		0.67	1.0	1.48	s
t_{VREL1}	Release Delay for VD1	$V_{DD} = 3.9$ V, V− = 0 V → 1 V		10.2	16	24.4	ms
V_{DET2}	Over-discharge Threshold	Detect falling edge of supply voltage		V_{DET2} −0.040	V_{DET2}	V_{DET2} +0.040	V
t_{VDET2}	Output Delay of Over-discharge	$V_{DD} = V_{DET2}$ + 0.13 V → V_{DET2} − 0.08 V		13.1	20	30	ms
t_{VREL2}	Release Delay for VD2	$V_{DD} = 1.9$ V → V_{DET2} + 0.08 V		0.65	1.2	1.93	ms
V_{DET31}	Excess Discharge-current Threshold	Detect rising edge of RSENS pin voltage	$V_{DET31} < 0.038$ V	V_{DET31} −0.0042	V_{DET31}	V_{DET31} -0.0042	V
			$V_{DET31} \geq 0.038$ V	V_{DET31} ×0.89	V_{DET31}	V_{DET31} ×1.11	V
t_{VDET31}	Output Delay of Excess Discharge-current 1	$V_{DD} = 3.0$ V, $V_{RSENS} = 0$ V to V_{DET31} x 1.18 V− = V_{RSENS}		t_{VDET31} ×0.66	t_{VDET31}	t_{VDET31} ×1.47	s
V_{DET32}	Excess Discharge-current Threshold	Detect rising edge of RSENS pin voltage, V− = 0 V	$V_{DET32} < 0.038$ V	V_{DET32} −0.0042	V_{DET32}	V_{DET32} -0.0042	V
			$V_{DET32} \geq 0.038$ V	V_{DET32} ×0.89	V_{DET32}	V_{DET32} ×1.11	V
t_{VDET32}	Output Delay of Excess Discharge-current 2	$V_{DD} = 3.0$ V, $V_{RSENS} = 0$ V to 0.1 V, V− = V_{RSENS}		7.4	12	18.5	ms
t_{VREL3}	Output Delay of Release from Excess Discharge-current	$V_{DD} = 3.1$ V, V− = 3.1 V to 0 V V− = V_{RSENS}		0.65	1.2	1.9	ms
V_{SHORT}	Short Protection Voltage	$V_{DD} = 3.1$ V, $V_{RSENS} = $ V−		V_{SHORT} −0.050	V_{SHORT}	V_{SHORT} +0.050	V
t_{SHORT}	Delay Time for Short Protection[1]	$V_{DD} = 3.1$ V, $V_{RSENS} = 0$ V to 3.1 V, V− = V_{RSENS}		160	250	490	µs
R_{SHORT}	Reset Resistance for Excess Current Protection	$V_{DD} = 3.6$ V, V− = 1.0 V		17.1	45	71	kΩ
V_{DET4}	Excess Charge-current Threshold	Detect falling edge of RSENS pin voltage, V− = 0 V	$V_{DET4} > -0.02$ V	V_{DET4} −0.0040	V_{DET4}	V_{DET4} -0.0040	V
			$V_{DET4} \leq -0.02$ V	V_{DET4} ×1.17	V_{DET4}	V_{DET4} ×0.83	V

[1] Output Delay Time for Release from Short Protection is the same value as t_{VREL3}.

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R5486K Electrical Characteristics (Continued)   **(-20°C < Ta < 60°C)**

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
t_{VDET4}	Output Delay of Excess Charge-current	V_{DD} = 3.1 V, V_{RSENS} = 0 V to −0.5 V, V− = V_{RSENS}	10.7	16	23.6	ms
t_{VREL4}	Output Delay of Release from Excess Charge-current	V_{DD} = 3.1 V, V− = −0.5 V to 0 V, V− = V_{RSENS}	0.65	1.2	1.93	ms
V_{DS}	Delay Time Shortening Mode Voltage	V_{DD} = 3.6 V	−2.7	−2.0	−1.2	V
V_{OL1}	Nch ON-Voltage of C_{OUT}	Iol = 50 µA, V_{DD} = 4.55 V		0.4	0.5	V
V_{OH1}	Pch ON-Voltage of C_{OUT}	Ioh = −50 µA, V_{DD} = 3.9 V	3.4	3.7		V
V_{OL2}	Nch ON-Voltage of D_{OUT}	Iol = 50 µA, V_{DD} = 1.9 V		0.2	0.5	V
V_{OH2}	Pch ON-Voltage of D_{OUT}	Ioh = −50 µA, V_{DD} = 3.9 V	3.4	3.7		V
I_{DD}	Supply Current	V_{DD} = 3.9 V, V− = 0 V		4.0	8.7	µA
Istandby	Standby Current	V_{DD} = 2.0 V			0.12	µA

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All of these specifications are guaranteed by design, not tested in mass production.

R5486K Electrical Characteristics   **(-40°C < Ta < 85°C)**

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_{NOCHG}	Maximum Operating Voltage for Inhibition of Charger	Voltage Defined as VDD–VSS, $V_{DD} - V- = 4$ V		V_{NOCHG} −0.423	V_{NOCHG}	V_{NOCHG} +0.44	V
V_{DET1}	Over-charge Threshold Voltage	R1 = 330 Ω		V_{DET1} −0.033	V_{DET1}	V_{DET1} +0.031	V
t_{VDET1}	Output Delay of Over-charge	$V_{DD} = 3.6$ V $\rightarrow V_{DET1} + 0.05$ V		0.67	1.0	1.55	s
t_{VREL1}	Release Delay for VD1	$V_{DD} = 3.9$ V, V− = 0 V $\rightarrow$ 1 V		10.2	16	26.0	ms
V_{DET2}	Over-discharge Threshold	Detect falling edge of supply voltage		V_{DET2} −0.043	V_{DET2}	V_{DET2} +0.040	V
t_{VDET2}	Output Delay of Over-discharge	$V_{DD} = V_{DET2} + 0.13$ V $\rightarrow V_{DET2} - 0.08$ V		13.1	20	31.8	ms
t_{VREL2}	Release Delay for VD2	$V_{DD} = 1.9$ V $\rightarrow V_{DET2} + 0.08$ V		0.65	1.2	2.04	ms
V_{DET31}	Excess Discharge-current Threshold	Detect rising edge of RSENS pin voltage	$V_{DET31} < 0.038$ V	V_{DET31} −0.0042	V_{DET31}	V_{DET31} +0.0042	V
			$V_{DET31} \geq 0.038$ V	V_{DET31} ×0.89	V_{DET31}	V_{DET31} ×1.11	V
t_{VDET31}	Output Delay of Excess Discharge-current 1	$V_{DD} = 3.0$ V, $V_{RSENS} = 0$ V to V_{DET31} x 1.18 V− = V_{RSENS}		t_{VDET31} ×0.66	t_{VDET31}	t_{VDET31} ×1.57	s
V_{DET32}	Excess Discharge-current Threshold	Detect rising edge of RSENS pin voltage, V− = 0 V	$V_{DET32} < 0.038$ V	V_{DET32} −0.0042	V_{DET32}	V_{DET32} +0.0042	V
			$V_{DET32} \geq 0.038$ V	V_{DET32} ×0.89	V_{DET32}	V_{DET32} ×1.11	V
t_{VDET32}	Output Delay of Excess Discharge-current 2	$V_{DD} = 3.0$ V, $V_{RSENS} = 0$ V to 0.1 V, V− = V_{RSENS}		7.4	12	19.7	ms
t_{VREL3}	Output Delay of Release from Excess Discharge-current	$V_{DD} = 3.1$ V, V− = 3.1 V to 0 V V− = V_{RSENS}		0.65	1.2	2.0	ms
V_{SHORT}	Short Protection Voltage	$V_{DD} = 3.1$ V, $V_{RSENS} = V-$		V_{SHORT} −0.050	V_{SHORT}	V_{SHORT} +0.050	V
t_{SHORT}	Delay Time for Short Protection[1]	$V_{DD} = 3.1$ V, $V_{RSENS} = 0$ V to 3.1 V, V− = V_{RSENS}		160	250	495	µs
R_{SHORT}	Reset Resistance for Excess Current Protection	$V_{DD} = 3.6$ V, V− = 1.0 V		14.4	45	71	kΩ
V_{DET4}	Excess Charge-current Threshold	Detect falling edge of RSENS pin voltage, V− = 0 V	$V_{DET4} > -0.02$ V	V_{DET4} −0.0041	V_{DET4}	V_{DET4} +0.0042	V
			$V_{DET4} \leq -0.02$ V	V_{DET4} ×1.17	V_{DET4}	V_{DET4} ×0.83	V

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[1] Output Delay Time for Release from Short Protection is the same value as t_{VREL3}.

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R5486K Electrical Characteristics (-40°C < Ta < 85°C)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
t_{VDET4}	Output Delay of Excess Charge-current	V_{DD} = 3.1 V, V_{RSENS} = 0 V to −0.5 V, V− = V_{RSENS}	10.7	16	28.3	ms
t_{VREL4}	Output Delay of Release from Excess Charge-current	V_{DD} = 3.1 V, V− = −0.5 V to 0 V, V− = V_{RSENS}	0.65	1.2	2.04	ms
V_{DS}	Delay Time Shortening Mode Voltage	V_{DD} = 3.6 V	−2.7	−2.0	−1.2	V
V_{OL1}	Nch ON-Voltage of C_{OUT}	Iol = 50 µA, V_{DD} = 4.55 V		0.4	0.5	V
V_{OH1}	Pch ON-Voltage of C_{OUT}	Ioh = −50 µA, V_{DD} = 3.9 V	3.4	3.7		V
V_{OL2}	Nch ON-Voltage of D_{OUT}	Iol = 50 µA, V_{DD} = 1.9 V		0.2	0.5	V
V_{OH2}	Pch ON-Voltage of D_{OUT}	Ioh = −50 µA, V_{DD} = 3.9 V	3.4	3.7		V
I_{DD}	Supply Current	V_{DD} = 3.9 V, V− = 0 V		4.0	9.08	µA
Istandby	Standby Current	V_{DD} = 2.0 V			0.12	µA

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APPLICATION INFORMATION
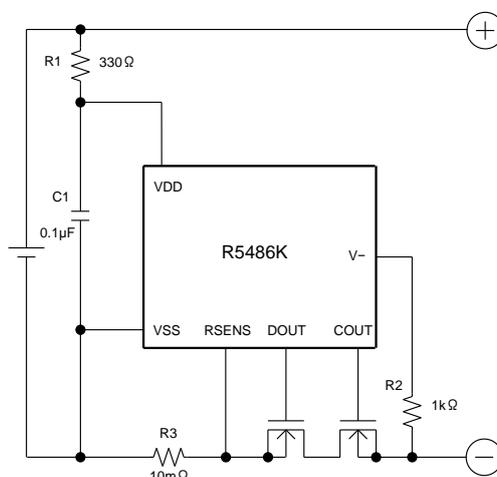
R5486K Typical Application Circuit

- R1 and C1 stabilize a supply voltage to the R5486K. A recommended R1 value is equal or less than 1 kΩ. A large value of R1 makes detection voltage shift higher because of the conduction current flowed in the R5486K. Further, to stabilize the operation of R5486K, use the C1 with the value of 0.01 μF or more.

- 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 R5486K, battery pack. While small value of R1 and R2 may cause over power dissipation rating of the R5486K, therefore a total of "R1+R2" should be 1 kΩ or more. Besides, if a large value of R2 is set, release from over-discharge by connecting a charger might not be possible. Recommended R2 value is equal or less than 10 kΩ.

- R3 is a resistor for sensing an excess current. If the resistance value is too large, power loss becomes also large. By the excess current, if the R3 is not appropriate, the power loss may be beyond the power dissipation of R3. Choose an appropriate R3 according to the cell specification.

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

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

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Sense resistance and on-resistance of the MOSFET selection guideline

Short mode is detected by the current base or the relation between V_{DD} at short and total on-resistance of external MOSFETs for COUT and DOUT.

If short must be detected by the current base determined by V_{SHORT} and R3, the next formula must be true, otherwise, the short current limit becomes $(V_{DD} - 0.9) / (R3 + R_{SS} (on))$

$$\frac{V_{DD} - 0.9}{R3 + R_{SS} (on)} \geq \frac{V_{SHORT}}{R3}$$

V_{SHORT} = Short Protection Voltage (V)

R3 = External Current Sense Resistance (Ω)

R_{SS} (on) = External MOSFETs' Total On-Resistance (Ω)

V_{DD} = V_{DD} level at short mode. If V_{DD} goes down by the short current, the lowest level is V_{DD}.

Ex. 1

As the R_{SENSE}, in case that the 5 mΩ is selected as R3 and if the V_{DD} becomes 3.0 V, to detect short at 36 A with V_{SHORT} = 0.18 V, the R_{SS} (on) must be 53 mΩ or lower.

Ex. 2

As the R_{SENSE}, in case the 10 mΩ is selected as R3 and if the V_{DD} becomes 3.0 V, to detect short at 18 A with V_{SHORT} = 0.18 V, the R_{SS} (on) must be 106 mΩ or lower.

If the R_{SS} (on) value is higher than the value calculated by this formula, the short current limit will be less than the desired value.

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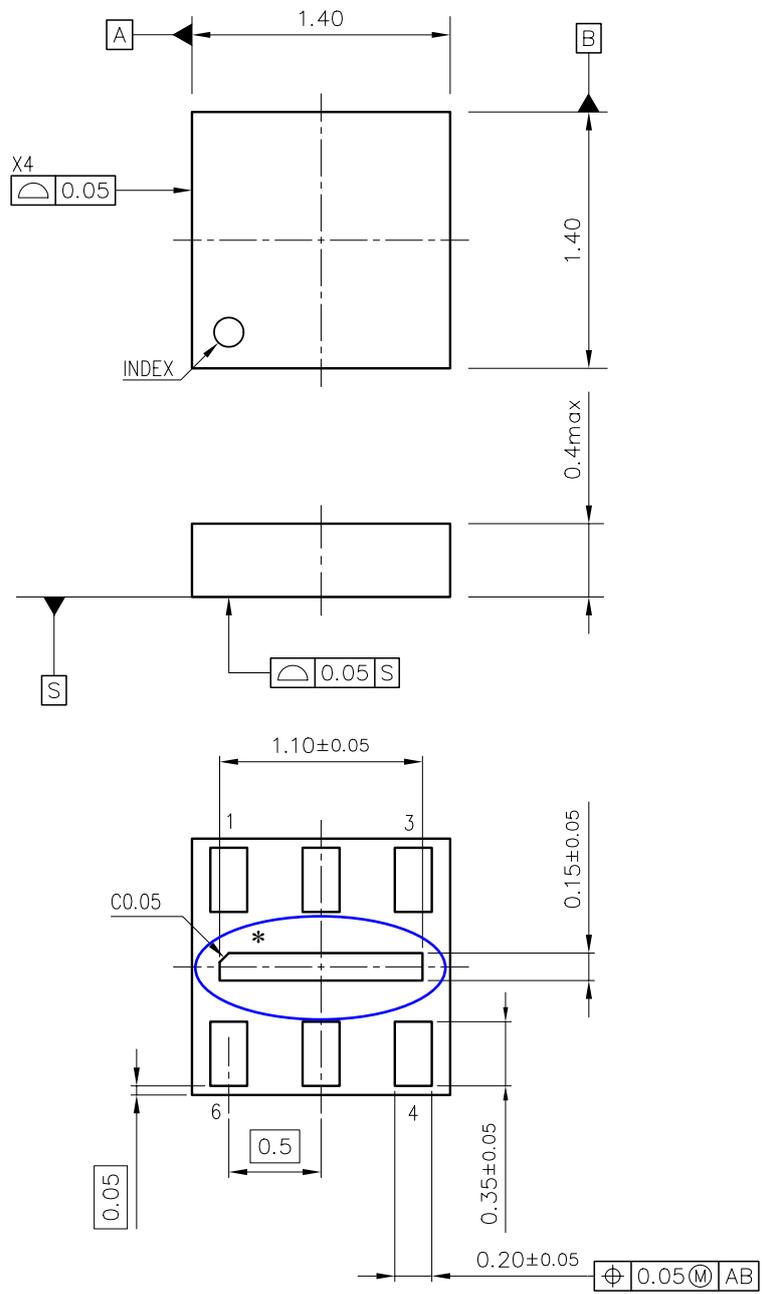
DFN(PLP)1414-6 Package Dimensions

∗ The tab on the bottom of the package shown by blue circle is a substrate potential (V_{DD}). It is recommended that this tab must be left floating.

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