Li-Ion/Li-Polymer 1-Cell Protector

NO. EA-339-221102

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)

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 to 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 ≤ $V_{DET31} \leq 0.035$	$V_{DET32} \geq 0.051$ 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

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

Product Code List

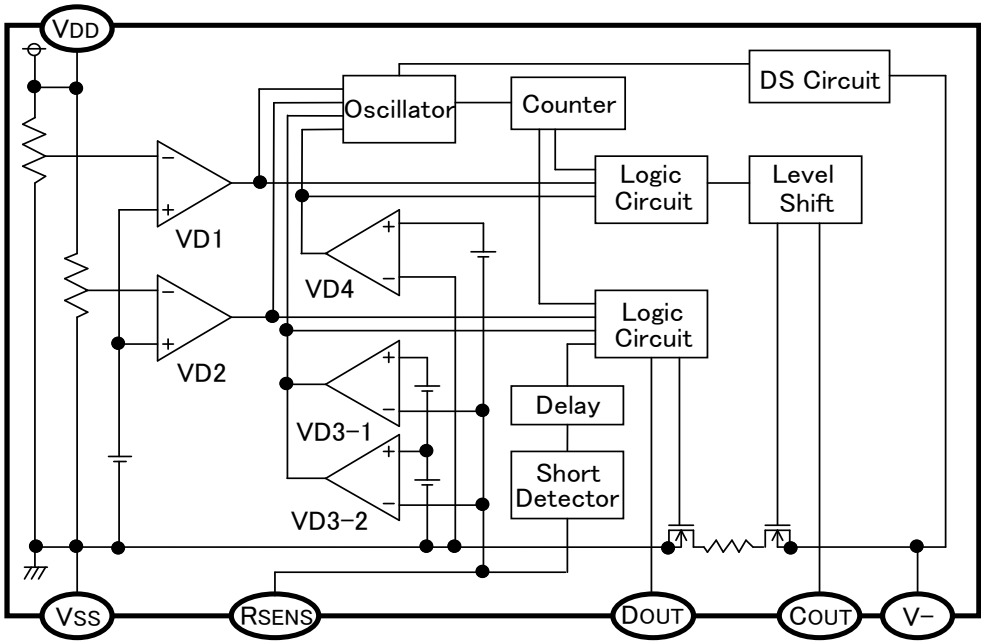
R5486KxxxCG Code List

Code	Set Voltage [V]							DelayTime [s]
	V_{DET1}	V_{DET2}	V_{DET31}	V_{DET32}	V_{DET4}	V_{SHORT}	V_{NOCHG}	t_{VDET31}
R5486KxxxCG:								
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
R5486K122CG	4.420	2.900	0.015	0.030	-0.015	0.150	1.500	3.0
R5486K123CG	4.280	3.000	0.015	0.030	-0.018	0.150	1.500	3.0
R5486KxxxCM:								
R5486K501CM	4.425	2.400	-	0.040	−0.022	0.300	1.500	-
R5486K502CM	4.425	2.600	-	0.052	−0.022	0.150	1.500	-
R5486K503CM	4.475	2.600	-	0.040	−0.025	0.250	0.700	-
R5486K504CM	4.425	2.400	-	0.040	−0.025	0.180	0.700	-
R5486K505CM	4.425	2.800	-	0.040	−0.030	0.150	1.500	-
R5486K506CM	4.425	2.600	-	0.030	−0.031	0.180	1.500	-
R5486K507CM	4.280	2.800	-	0.040	−0.030	0.150	1.500	-

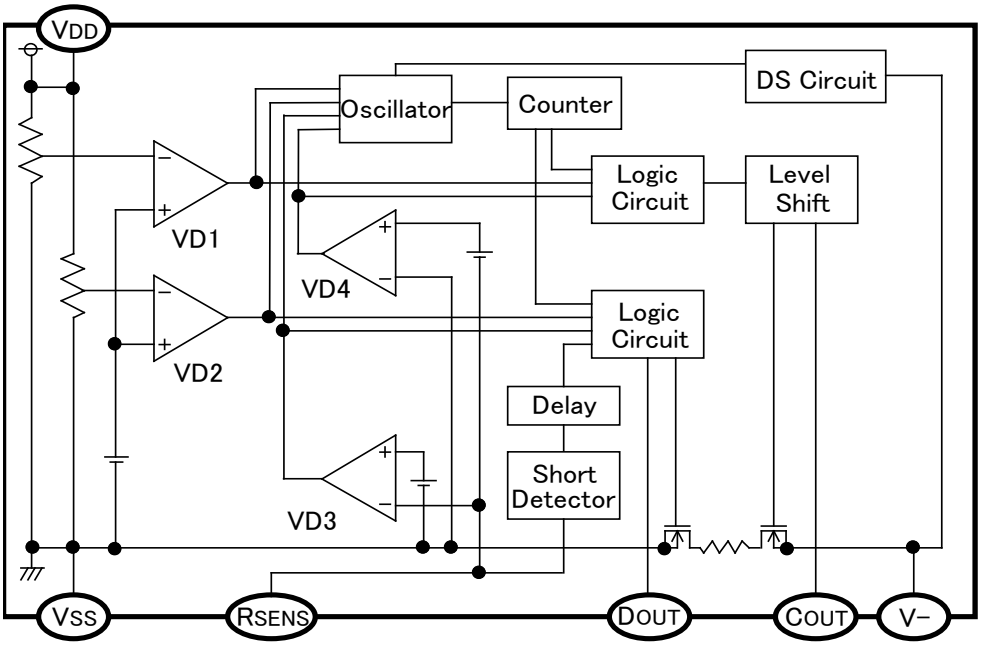
R5486KxxxCM Code List (Continued)

Code	Set Voltage [V]							DelayTime [s]
	V_{DET1}	V_{DET2}	V_{DET31}	V_{DET32}	V_{DET4}	V_{SHORT}	V_{NOCHG}	t_{VDET31}
R5486K508CM	4.230	2.800	-	0.050	−0.030	0.150	1.500	-
R5486K509CM	4.425	2.800	-	0.050	−0.030	0.150	1.500	-
R5486K510CM	4.280	2.800	-	0.050	−0.030	0.150	1.500	-
R5486K511CM	4.280	2.400	-	0.033	−0.024	0.150	1.500	-
R5486K512CM	4.405	2.800	-	0.040	−0.030	0.150	1.500	-
R5486K513CM	4.405	2.400	-	0.033	−0.024	0.150	1.500	-
R5486K514CM	4.450	2.600	-	0.040	−0.030	0.150	1.500	-
R5486K515CM	4.280	2.400	-	0.040	−0.030	0.150	1.500	-
R5486K516CM	4.425	2.800	-	0.050	−0.055	0.250	1.500	-
R5486K517CM	4.425	2.800	-	0.065	−0.060	0.180	1.500	-
R5486K518CM	4.425	2.400	-	0.034	−0.023	0.180	0.700	-
R5486K519CM	4.475	2.400	-	0.040	−0.025	0.180	0.700	-
R5486K520CM	4.425	2.400	-	0.030	−0.060	0.180	0.700	-
R5486K521CM	4.420	2.500	-	0.035	−0.030	0.150	0.700	-
R5486K522CM	4.475	2.400	-	0.042	−0.025	0.180	0.700	-
R5486K523CM	4.420	2.500	-	0.028	−0.025	0.150	0.700	-
R5486K524CM	4.425	2.800	-	0.026	−0.026	0.150	1.500	-
R5486K525CM	4.475	2.800	-	0.040	−0.025	0.180	0.700	-
R5486K526CM	4.475	2.600	-	0.040	−0.025	0.180	0.700	-
R5486K527CM	4.475	2.800	-	0.025	−0.021	0.150	1.500	-
R5486K528CM	4.475	2.500	-	0.045	−0.035	0.150	0.700	-
R5486K529CM	4.475	2.500	-	0.045	−0.036	0.150	0.700	-
R5486K530CM	4.475	2.600	-	0.046	−0.031	0.150	0.700	-
R5486K531CM	4.230	2.800	-	0.035	−0.018	0.150	1.500	-
R5486K532CM	4.230	2.600	-	0.035	−0.018	0.150	1.500	-
R5486K533CM	4.230	2.800	-	0.045	−0.015	0.150	1.500	-
R5486K534CM	4.230	2.600	-	0.045	−0.015	0.150	1.500	-
R5486K536CM	4.500	2.900	-	0.025	-0.023	0.150	1.500	-
R5486K537CM	4.550	2.600	-	0.040	-0.040	0.180	0.700	-
R5486K538CM	4.550	2.600	-	0.045	-0.040	0.180	0.700	-
R5486K539CM	4.480	2.800	-	0.040	−0.025	0.150	1.500	-
R5486K540CM	4.600	2.500	-	0.050	−0.057	0.250	0.700	-
R5486K541CM	4.550	2.600	-	0.055	−0.040	0.150	0.700	-
R5486K542CM	4.600	2.500	-	0.060	−0.057	0.180	0.700	-
R5486K544CM	4.600	2.100	-	0.065	−0.057	0.250	0.700	-

BLOCK DIAGRAMS

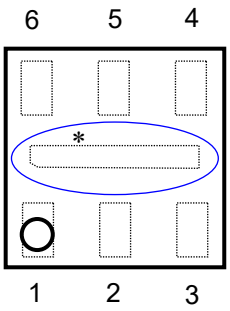


R5486KxxxCG Block Diagram



R5486KxxxCM Block Diagram

PIN DESCRIPTION



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

* The tab on the bottom of the package shown by blue circle is no connection.

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

ABSOLUTE MAXIMUM RATINGS

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

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

ELECTRICAL CHARACTERISTICS

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 → 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 → 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 → V_{DET2} − 0.08 V		14	20	26	ms
t_{VREL2}	Release Delay for VD2	V_{DD} = 1.9 V → 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} ≥ 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_{VDET}31	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} ≥ 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} ≤ −0.02 V	V_{DET4} ×1.15	V_{DET4}	V_{DET4} ×0.85	V

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

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

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} ≥ 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} ≥ 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} ≤ −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}.

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

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

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

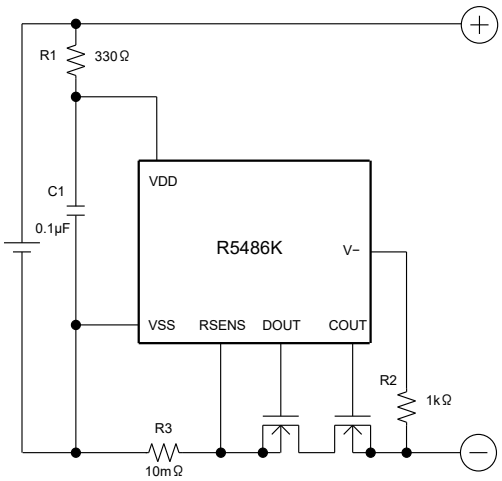
Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_{NOCHG}	Maximum Operating Voltage for Inhibition of Charger	Voltage Defined as VDD–VSS, V_{DD} − V− = 4 V		V_{NOCHG} −0.423	V_{NOCHG}	V_{NOCHG} +0.44	V
V_{DET1}	Over-charge Threshold Voltage	R1 = 330 Ω		V_{DET1} −0.033	V_{DET1}	V_{DET1} +0.031	V
t_{VDET1}	Output Delay of Over-charge	V_{DD} = 3.6 V → 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 → 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 → V_{DET2} − 0.08 V		13.1	20	31.8	ms
t_{VREL2}	Release Delay for VD2	V_{DD} = 1.9 V → 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} ≥ 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} ≥ 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} ≤ −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}.

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

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.

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.

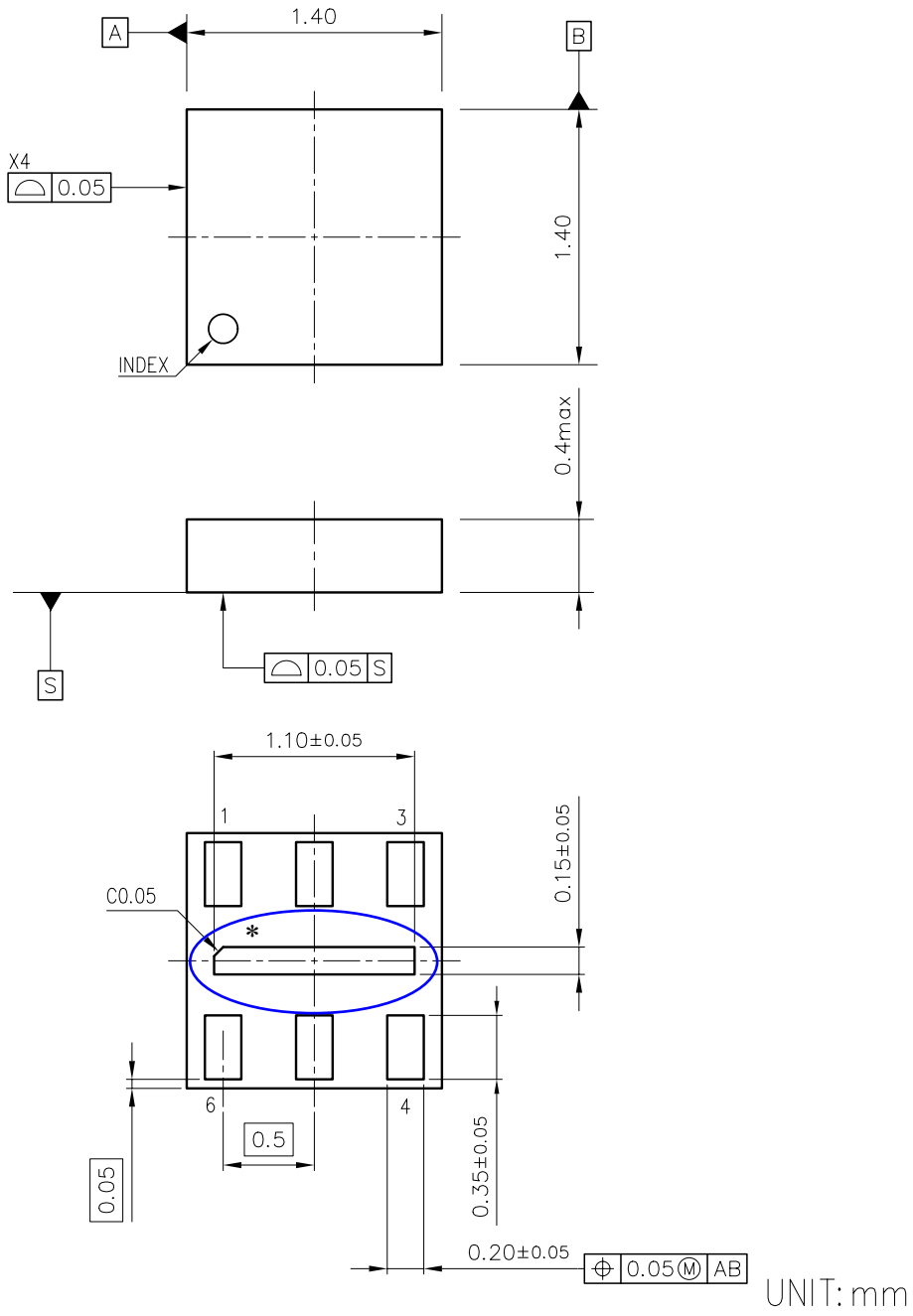
Ex. 2
As the R_{SENSE}, in case the 10 mΩ is selected as R3 and if the V_{DD} becomes 3.0 V, to detect short at 18 A with V_{SHORT} = 0.18 V, the R_{SS} (on) must be 106 mΩ or lower.

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.

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).

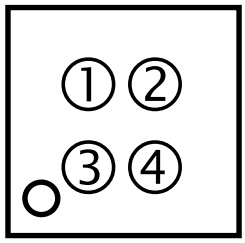


DFN(PLP)1414-6 Package Dimensions

* The tab on the bottom of the package shown by blue circle is No Connection.

Ver. D

①②: Product Code ⋯ Refer to *Part Marking List*
③④: Lot Number ⋯ Alphanumeric Serial Number



R5486K [DFN(PLP)1414-6] 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.

R5480K Part Marking List

Product Name	① ②	Product Name	① ②	Product Name	① ②
R5486K101CG	F0	R5486K524CM	K1		
R5486K102CG	F1	R5486K115CG	K2		
R5486K501CM	F2	R5486K525CM	K3		
R5486K502CM	F3	R5486K526CM	K4		
R5486K503CM	F4	R5486K527CM	K5		
R5486K504CM	F5	R5486K528CM	K6		
R5486K506CM	F6	R5486K529CM	K7		
R5486K103CG	F7	R5486K530CM	K8		
R5486K104CG	F8	R5486K116CG	K9		
R5486K505CM	F9	R5486K117CG	L0		
R5486K507CM	G1	R5486K118CG	L1		
R5486K508CM	G2	R5486K119CG	L2		
R5486K509CM	G3	R5486K531CM	L3		
R5486K510CM	G4	R5486K532CM	L4		
R5486K511CM	G5	R5486K533CM	L5		
R5486K512CM	G6	R5486K534CM	L6		
R5486K513CM	G7	R5486K120CG	L7		
R5486K514CM	G8	R5486K121CG	L8		
R5486K515CM	G9	R5486K536CM	L9		
R5486K516CM	H1	R5486K537CM	M0		
R5486K105CG	H2	R5486K538CM	M1		
R5486K106CG	H3	R5486K539CM	M2		
R5486K107CG	H4	R5486K122CG	M3		
R5486K517CM	H5	R5486K123CG	M4		
R5486K518CM	H6	R5486K540CM	M5		
R5486K519CM	H7	R5486K541CM	M6		
R5486K108CG	H8	R5486K542CM	M7		
R5486K109CG	H9	R5486K544CM	M8		
R5486K520CM	J1				
R5486K110CG	J2				
R5486K521CM	J3				
R5486K111CG	J4				
R5486K522CM	J5				
R5486K112CG	J6				
R5486K523CM	J7				
R5486K113CG	J8				
R5486K114CG	J9				

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    - Aerospace Equipment
    - Equipment Used in the Deep Sea
    - Power Generator Control Equipment (nuclear, steam, hydraulic, etc.)
    - Life Maintenance Medical Equipment
    - Fire Alarms / Intruder Detectors
    - Vehicle Control Equipment (automotive, airplane, railroad, ship, etc.)
    - Various Safety Devices
    - Traffic control system
    - Combustion equipment

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

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