1-Cell Li-Ion Battery Protection IC

NO.EA-308-201211

OUTLINE

The R5480x is a protection IC for over-charge of rechargeable Lithium-ion (Li+)/Lithium polymer battery. The R5480x can detect over-charge, over-discharge, excess-discharge current, and excess-charge current of one-cell Lithium-ion (Li+)/Lithium polymer battery. The external resistor of RSENSE pin allows a high-accuracy detection for excess current. The supply current after detecting over-discharge is suppressed as much as possible by stopping the internal circuit.

FEATURES

- High Voltage Tolerant Process
  Absolute Maximum Ratings ..... 30 V
- Low supply current
  Supply current (At normal mode) ..... Typ. 4.0 µA
  Standby current ..... Max. 0.1 µA
- High accuracy detector threshold
  Over-charge detector ..... ±20 mV (≤ 4.5 V) / ±25 mV (> 4.5 V)
  Over-discharge detector ..... ±35 mV
  Excess discharge-current detector ..... ±15% (≥ 30 mV) / ±4.5 mV (< 30 mV)
  Excess charge-current detector ..... ±15%
- Variety of detector threshold
  Over-charge detector threshold ..... 4.1 V to 4.7 V in step of 0.005 V
  Over-discharge detector threshold ..... 2.1 V to 3.0 V in step of 0.050 V
  Excess discharge-current threshold ..... 0.020 V to 0.050 V in step of 0.001 V
  Excess charge-current threshold ..... −0.057 V to −0.020 V in step of 0.001 V
- Internal fixed Output delay time
  Over-charge detector Output Delay ..... 1.0 s
  Over-discharge detector Output Delay ..... 20 ms / 132 ms
  Excess discharge-current detector Output Delay ..... 12 ms
  Excess charge-current detector Output Delay ..... 16 ms / 8 ms
  Short Circuit detector Output Delay ..... 250 µs
- Output Delay Time Shortening Function
  When the V- level is set at −2.0 V (typ.) during the COUT pin of “High”, the output delay time for the over-charge and the over-discharge detections can be reduced (Delay time for over-charge becomes about 1/100 that of the normal state).
- Conditions for release over-charge detector ..... Latch type
- Conditions for release over-discharge detector ..... Latch type
- 0 V-battery charge option ..... Unacceptable
- Small package ..... DFN(PLP)1414-6

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 over-charge and the delay time are user-selectable options.

Selection Guide

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R5480Kxxx$∗-TR	DFN(PLP)1414-6	5,000 pcs	Yes	Yes

xxx: Set Voltage Code. Refer to *"Product Code List"* for details.

$: Delay Time Code

Code	t_{VDET1} [s]	t_{VDET2} [ms]	t_{VDET3} [ms]	t_{VDET4} [ms]	t_{SHORT} [µs]
C	1	20	12	16	250
U	1	132	12	8	250

∗: Function Code

Code	Return from Over-charge	Return from Over-discharge	0-V Charge	V_{DET3} [mV]	V_{DET4} [mV]	V_{SHORT} [V]
G	Latch	Latch	NG	30 to 50	-30 to -20	0.500
L	Latch	Latch	NG	30 to 50	-30 to -20	0.180
M	Latch	Latch	NG	30 to 50	-30 to -20	0.140
N	Latch	Latch	NG	20 to 25	-30 to -20	0.140
P	Latch	Latch	NG	30 to 50	-57 to -30	0.250
Q	Latch	Latch	NG	30 to 50	-57 to -30	0.180
R	Latch	Latch	NG	25 to 30	-30 to -20	0.140

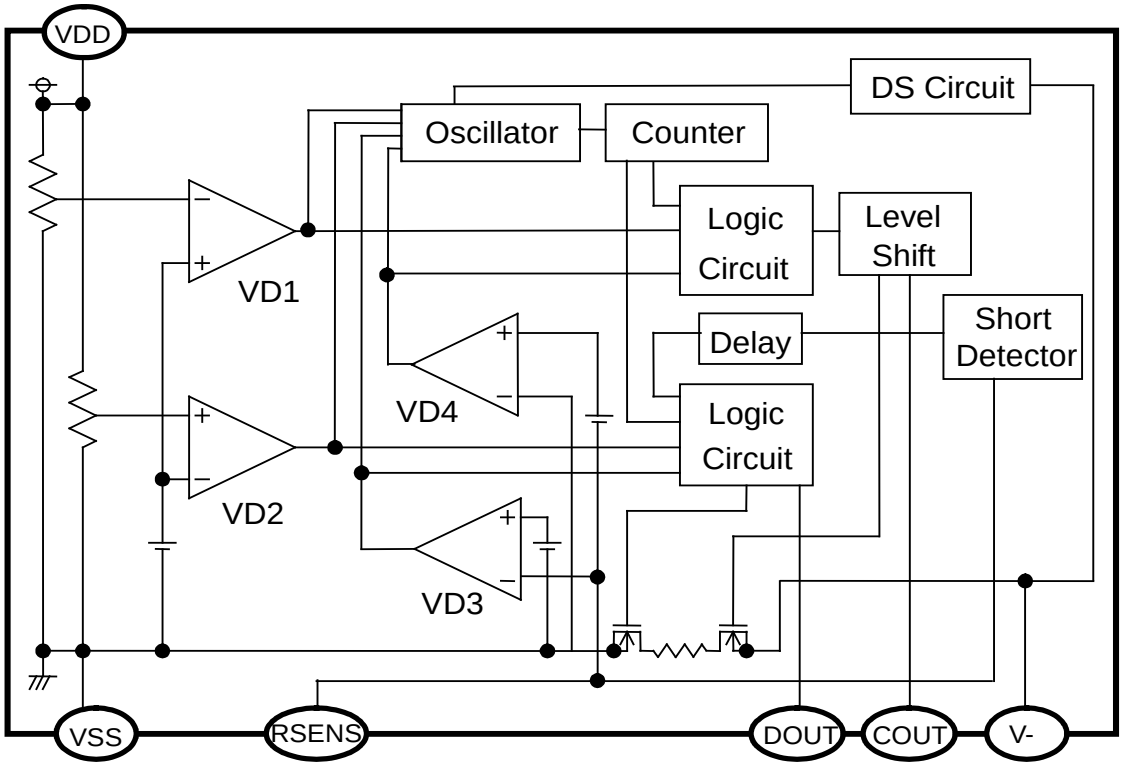
R5480K Code List

Product Code	Set Output Voltage [V]							Delay Time					Func-tion
	V_{DET1}	V_{REL1}	V_{DET2}	V_{REL2}	V_{DET3}	V_{DET4}	V_{SHORT}	t_{VDET1} [s]	t_{VDET2} [ms]	t_{VDET3} [ms]	t_{VDET4} [ms]	t_{SHORT} [µs]	0V Charge
R5480K228CG	4.405	-	2.400	-	0.032	-0.020	0.500	1	20	12	16	250	NG
R5480K240CG	4.280	-	2.800	-	0.032	-0.020	0.500	1	20	12	16	250	NG
R5480K241CG	4.405	-	2.400	-	0.042	-0.020	0.500	1	20	12	16	250	NG
R5480K247CG	4.425	-	2.400	-	0.032	-0.020	0.500	1	20	12	16	250	NG
R5480K257CL	4.425	-	2.400	-	0.034	-0.022	0.180	1	20	12	16	250	NG
R5480K260CL	4.280	-	2.400	-	0.032	-0.030	0.180	1	20	12	16	250	NG
R5480K261CL	4.280	-	2.700	-	0.040	-0.030	0.180	1	20	12	16	250	NG
R5480K262CL	4.405	-	2.400	-	0.040	-0.030	0.180	1	20	12	16	250	NG
R5480K266CL	4.475	-	2.800	-	0.040	-0.030	0.180	1	20	12	16	250	NG
R5480K267CL	4.475	-	2.400	-	0.034	-0.022	0.180	1	20	12	16	250	NG
R5480K228CL	4.405	-	2.400	-	0.032	-0.020	0.180	1	20	12	16	250	NG
R5480K275CL	4.230	-	2.800	-	0.048	-0.030	0.180	1	20	12	16	250	NG
R5480K277CL	4.425	-	2.800	-	0.040	-0.030	0.180	1	20	12	16	250	NG
R5480K278CL	4.425	-	2.800	-	0.034	-0.022	0.180	1	20	12	16	250	NG
R5480K283CL	4.280	-	2.800	-	0.030	-0.020	0.180	1	20	12	16	250	NG
R5480K284CL	4.425	-	2.400	-	0.040	-0.030	0.180	1	20	12	16	250	NG
R5480K285CL	4.280	-	2.400	-	0.040	-0.030	0.180	1	20	12	16	250	NG
R5480K286CL	4.405	-	2.800	-	0.040	-0.030	0.180	1	20	12	16	250	NG
R5480K287CL	4.280	-	2.600	-	0.048	-0.030	0.180	1	20	12	16	250	NG
R5480K324CL	4.425	-	2.500	-	0.030	-0.030	0.180	1	20	12	16	250	NG
R5480K326CL	4.280	-	2.800	-	0.048	-0.030	0.180	1	20	12	16	250	NG
R5480K348CL	4.475	-	2.600	-	0.040	-0.030	0.180	1	20	12	16	250	NG
R5480K342UM	4.425	-	2.800	-	0.030	-0.023	0.140	1	132	12	8	250	NG
R5480K349CL	4.475	-	2.600	-	0.048	-0.030	0.180	1	20	12	16	250	NG
R5480K354CL	4.425		2.400		0.030	-0.029	0.180	1	20	12	16	250	NG
R5480K355CL	4.500		2.600		0.040	-0.030	0.180	1	20	12	16	250	NG

R5480K Code List (Continued)

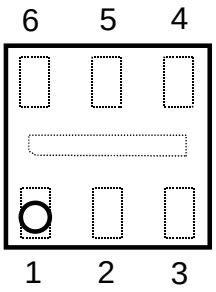
Product Code	Set Output Voltage [V]							Delay Time					Func-tion
	V_{DET1}	V_{REL1}	V_{DET2}	V_{REL2}	V_{DET3}	V_{DET4}	V_{SHORT}	t_{VDET1} [s]	t_{VDET2} [ms]	t_{VDET3} [ms]	t_{VDET4} [ms]	t_{SHORT} [µs]	0V Charge
R5480K601CN	4.500	-	2.900	-	0.020	-0.023	0.140	1	20	12	16	250	NG
R5480K602CQ	4.550	-	2.600	-	0.040	-0.040	0.180	1	20	12	16	250	NG
R5480K603CP	4.600	-	2.500	-	0.050	-0.057	0.250	1	20	12	16	250	NG
R5480K604CR	4.420	-	2.500	-	0.028	-0.020	0.140	1	20	12	16	250	NG

BLOCK DIAGRAM



R5480K Block Diagram

PIN DESCRIPTION



R5480K (DFN(PLP)1414-6) Pin Configuration

R5480K 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	RSENSE	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	Item	Rating	Unit
V_{DD}	Supply Voltage	−0.3 to 12.0	V
V−	V− Pin Voltage	V_{DD} - 30 to V_{DD} + 0.3	V
R_{SENSE}	RSENSE Pin Voltage	V_{SS} - 0.3 to V_{DD} + 0.3	V
V_{COUT}	COUT Pin Voltage	V_{DD} - 30 to V_{DD} + 0.3	V
V_{DOUT}	DOUT Pin Voltage	V_{SS} - 0.3 to V_{DD} + 0.3	V
P_D	Power Dissipation (Standard Land Pattern)	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	Item	Rating	Unit
V_{DD}	Operating Input Voltage	−0.3 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

R5480K Electrical Characteristics (Unless otherwise specified, Ta = 25°C)

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit	Circuit (1)
V_{DD1}	Operating Input Voltage	V_{DD} - V_{SS}		1.5		5.0	V	A
V_{NOCHG}	Maximum Operating Voltage for Inhibition of Charger	Voltage Defined as V_{DD} - V_{SS}, V_{DD} - V− = 4 V		0.4	0.7	1.0	V	A
V_{DET1}	Over-charge Threshold Voltage	R1 = 330 Ω	≤ 4.5V	V_{DET1} −0.020	V_{DET1}	V_{DET1} +0.020	V	B
			> 4.5V	V_{DET1} −0.025		V_{DET1} +0.025		
t_{VDET1}	Output Delay of Over-charge	V_{DD} = 3.6 V→V_{DET1}+0.05V		0.7	1.0	1.3	s	B
t_{VREL1}	Release Delay for VD1	V_{DD} = 4V, V− = 0V → 1V		11	16	21	ms	C
V_{DET2}	Over-discharge Threshold	Detect falling edge of supply voltage		V_{DET2} −0.035	V_{DET2}	V_{DET2} +0.035	V	D
t_{VDET2}	Output Delay of Over-discharge (R5480KxxxCG/CL/CN/CP/CQ/CR)	V_{DD} = 3.6 V → 2.0 V		14	20	26	ms	D
	Output Delay of Over-discharge (R5480KxxxUM)			92	132	172		
t_{VREL2}	Release Delay for VD2	V_{DD} = 3V, V− = 3V → 0V		0.7	1.2	1.7	ms	E
V_{DET3}	Excess discharge-current threshold	Detect rising edge of V_{RSENSE}, V− = V_{RSENSE}	≥ 30 mV	V_{DET3} x0.85	V_{DET3}	V_{DET3} x1.15	V	F
			< 30 mV	V_{DET3} −0.0045		V_{DET3} +0.0045		
t_{VDET3}	Output delay of excess discharge-current (R5480KxxxCG/CL/CN/CP/CQ/CR)	V_{DD} = 3.0 V, V_{RSENSE} = 0 V → 0.12 V, V− = V_{RSENSE}		8	12	16	ms	F
	Output delay of excess discharge-current (R5480KxxxUM)			9	12	16		
t_{VREL3}	Output delay of release from excess discharge-current	V_{DD} = 3.0V, V- = 3V → 0V, V− = V_{RSENSE}		0.7	1.2	1.7	ms	F
V_{SHORT}	Short protection voltage (R5480KxxxCG)	V_{DD} = 3.0 V, V_{RSENSE} = V−		0.41	0.50	0.59	V	F
	Short protection voltage (R5480KxxxCL/CQ)			0.135	0.18	0.225		
	Short protection voltage (R5480KxxxUM/CN/CR)			0.095	0.14	0.185		
	Short protection voltage (R5480KxxxCP)			0.205	0.250	0.295		
t_{SHORT}	Output Delay of Short protection	V_{DD} = 3.0 V, V_{RSENSE} = 0 V → 3 V, V− = V_{RSENSE}		180	250	425	μs	F
R_{SHORT}	Reset resistance for excess discharge-current protection	V_{DD} = 3.6 V, V− = 1.0 V		20	45	70	kΩ	F

(1) Refer to *Test Circuits* for details.

R5480K Electrical Characteristics (Continued) (Unless otherwise specified, Ta = 25°C)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit	Circuit (1)
V_{DET4}	Excess charge-current threshold	Detect falling edge of V_{RSENSE}, V− = V_{RSENSE}	V_{DET4} x1.15	V_{DET4}	V_{DET4} x0.85	V	G
t_{VDET4}	Output delay of excess charge-current (R5480KxxxCG/CL/CN/CP/CQ/CR)	V_{DD} = 3.0 V, V_{RSENSE} = 0 V → −0.3 V, V− = V_{RSENSE}	11	16	21	ms	G
	Output delay of excess charge-current (R5480KxxxUM)		5	8	11		
t_{VREL4}	Output delay of release from excess charge-current	V_{DD} = 3.0 V, V− = −1 V → 0 V, V− = V_{RSENSE}	0.7	1.2	1.7	ms	G
V_{DS}	Delay Time Shortening Mode Voltage	V_{DD} = 3.6 V	−2.6	−2.0	−1.4	V	G
V_{OL1}	Nch ON-Voltage of C_{OUT}	I_{OL} = 50 µA, V_{DD} = 4.5 V		0.4	0.5	V	H
V_{OH1}	Pch ON-Voltage of C_{OUT}	I_{OH} = −50 µA, V_{DD} = 3.9 V	3.4	3.7		V	I
V_{OL2}	Nch ON-Voltage of D_{OUT}	I_{OL} = 50 µA, V_{DD} = 2.0 V		0.2	0.5	V	J
V_{OH2}	Pch ON-Voltage of D_{OUT}	I_{OH} = −50 µA, V_{DD} = 3.9 V	3.4	3.7		V	K
I_{DD}	Supply Current	V_{DD} = 3.9 V, V− = 0 V		4.0	8.0	µA	L
$I_{STANDBY}$	Standby Current	V_{DD} = 2.0 V			0.1	µA	L

(1) Refer to *Test Circuits* for details.

R5480K Electrical Characteristics (Continued) (-20°C ≤ Ta ≤ 60°C)

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit	Circuit (1)
V_{DD1}	Operating Input Voltage	V_{DD} - V_{SS}		1.5		5.0	V	A
V_{NOCHG}	Maximum Operating Voltage for Inhibition of Charger	Voltage Defined as V_{DD} - V_{SS}, V_{DD} - V− = 4 V		0.27	0.7	1.1	V	A
V_{DET1}	Over-charge Threshold Voltage	R1 = 330 Ω	≤ 4.5V	V_{DET1} −0.025	V_{DET1}	V_{DET1} +0.025	V	B
			> 4.5V	V_{DET1} −0.030		V_{DET1} +0.030		
t_{VDET1}	Output Delay of Over-charge	V_{DD}=3.6V→ V_{DET1}+0.05V		0.67	1.0	1.55	s	B
t_{VREL1}	Release Delay for VD1	V_{DD} = 4 V, V− = 0V → 1V		10.7	16	24.8	ms	C
V_{DET2}	Over-discharge Threshold	Detect falling edge of supply voltage		V_{DET2} −0.040	V_{DET2}	V_{DET2} +0.040	V	D
t_{VDET2}	Output Delay of Over-discharge (R5480KxxxCG/CL/CN/CP/CQ/CR)	V_{DD} = 3.6 V → 2.0 V		13.4	20	31	ms	D
	Output Delay of Over-discharge (R5480KxxxUM)			88.4	132	204.6		
t_{VREL2}	Release Delay for VD2	V_{DD} = 3 V, V− = 3V → 0V		0.65	1.2	1.86	ms	E
V_{DET3}	Excess discharge-current threshold	Detect rising edge of V_{RSENSE}, V− = V_{RSENSE}	≥ 30mV	V_{DET3} x0.83	V_{DET3}	V_{DET3} x1.17	V	F
			< 30mV	V_{DET3} −0.0052		V_{DET3} +0.0052		
t_{VDET3}	Output delay of excess discharge-current (R5480KxxxCG/CL/CN/CP/CQ/CR)	V_{DD} = 3.0 V, V_{RSENSE} = 0 V → 0.12 V, V− = V_{RSENSE}		7.5	12	18.6	ms	F
	Output delay of excess discharge-current (R5480KxxxUM)			8.5				
t_{VREL3}	Output delay of release from excess discharge-current	V_{DD} = 3.0V, V- = 3V→0V V− = V_{RSENSE}		0.65	1.2	1.86	ms	F
V_{SHORT}	Short protection voltage (R5480KxxxCG)	V_{DD} = 3.0 V, V_{RSENSE} = V−		0.400	0.500	0.600	V	F
	Short protection voltage (R5480KxxxCL/CQ)			0.125	0.180	0.235		
	Short protection voltage (R5480KxxxUM/CN/CR)			0.085	0.140	0.195		
	Short protection voltage (R5480KxxxCP)			0.195	0.250	0.305		
t_{SHORT}	Output Delay of Short protection	V_{DD} = 3.0 V, V_{RSENSE} = 0 V → 3 V, V− = V_{RSENSE}		160	250	490	µs	F
R_{SHORT}	Reset resistance for excess discharge-current protection	V_{DD} = 3.6 V, V− = 1.0 V		17.3	45	73.3	kΩ	F

(1) Refer to *Test Circuits* for details.

R5480K Electrical Characteristics (Continued) (-20°C ≤ Ta ≤ 60°C)

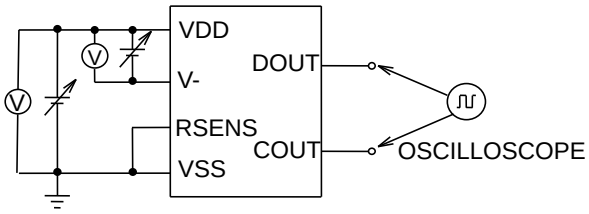
Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit	Circuit (1)
V_{DET4}	Excess charge-current threshold	Detect falling edge of V_{RSENSE}, V− = V_{RSENSE}	V_{DET4} x1.17	V_{DET4}	V_{DET4} x0.83	V	G
t_{VDET4}	Output delay of excess charge-current (R5480KxxxCG/CL/CN/CP/CQ/CR)	V_{DD} = 3.0 V, V_{RSENSE} = 0 V → −0.3 V, V− = V_{RSENSE}	10.7	16	24.8	ms	G
	Output delay of excess charge-current (R5480KxxxUM)		4.8	8	12.4		
t_{VREL4}	Output delay of release from excess charge-current	V_{DD} = 3.0 V, V− = −1 V → 0 V V− = V_{RSENSE}	0.65	1.2	1.86	ms	G
V_{DS}	Delay Time Shortening Mode Voltage	V_{DD} = 3.6 V	−2.7	−2.0	−1.2	V	G
V_{OL1}	Nch ON-Voltage of C_{OUT}	I_{OL} = 50 µA, V_{DD} = 4.5 V		0.4	0.5	V	H
V_{OH1}	Pch ON-Voltage of C_{OUT}	I_{OH} = −50 µA, V_{DD} = 3.9 V	3.4	3.7		V	I
V_{OL2}	Nch ON-Voltage of D_{OUT}	I_{OL} = 50 µA, V_{DD} = 2.0 V		0.2	0.5	V	J
V_{OH2}	Pch ON-Voltage of D_{OUT}	I_{OH} = −50 µA, V_{DD} = 3.9 V	3.4	3.7		V	K
I_{DD}	Supply Current	V_{DD} = 3.9 V, V− =0 V		4.0	8.7	µA	L
$I_{STANDBY}$	Standby Current	V_{DD} = 2.0 V			0.12	µA	L

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

(1) Refer to *Test Circuits* for details.

Test Circuits

A



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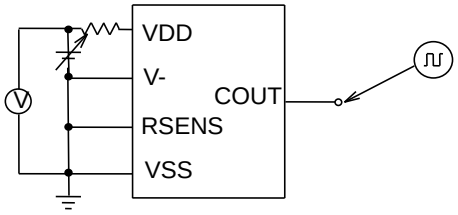

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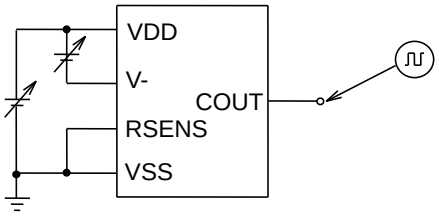

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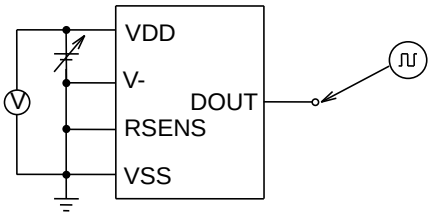

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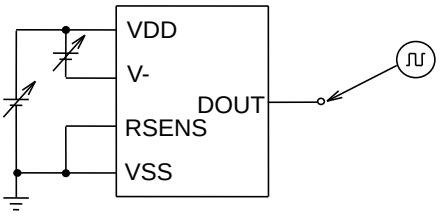

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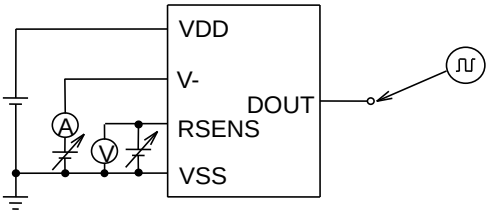

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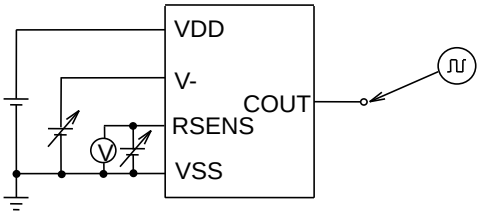

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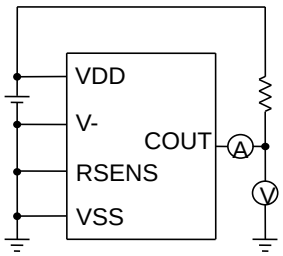

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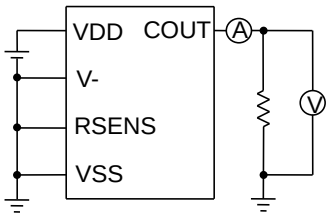

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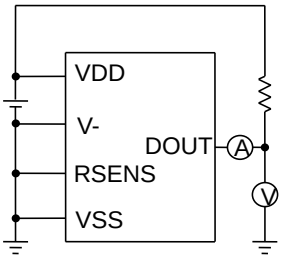

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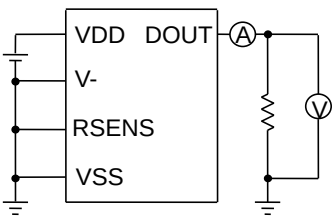

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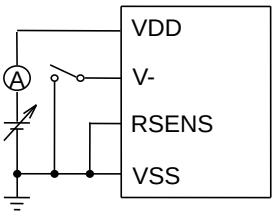
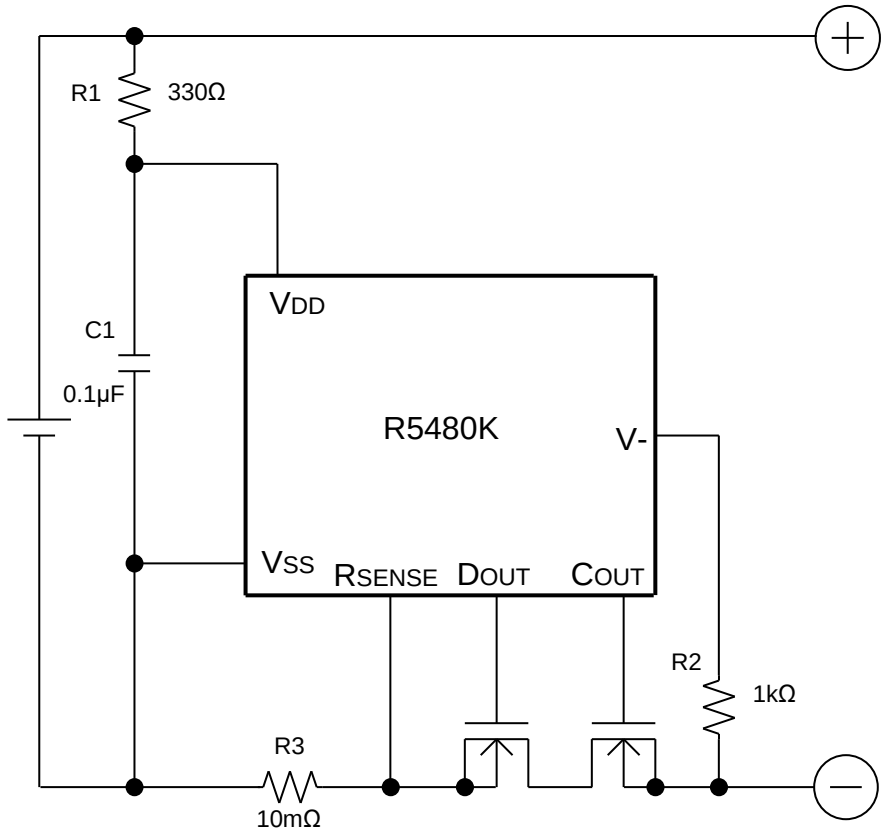


APPLICATION INFORMATION

Typical Application Circuit



Guidelines for Component Selection

R1 and C1 stabilize a supply voltage to the R5480. A recommended R1 value is equal or less than 1kΩ. A large value of R1 makes detection voltage shift higher because of the conduction current flowed in the R5480x. Further, to stabilize the operation of R5480K, use the C1 with the value of 0.01μF 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 R5480K, battery pack. While small value of R1 and R2 may cause over power dissipation rating of the R5480K, therefore a total of "R1+R2" should be 1kΩ 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 10kΩ.

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 VDD 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 (VDD - 0.9)/(R3 + $R_{SS(ON)}$)

$$\frac{VDD - 0.9}{R3 + RSS\,(on)} \geq \frac{VSHORT}{R3}$$

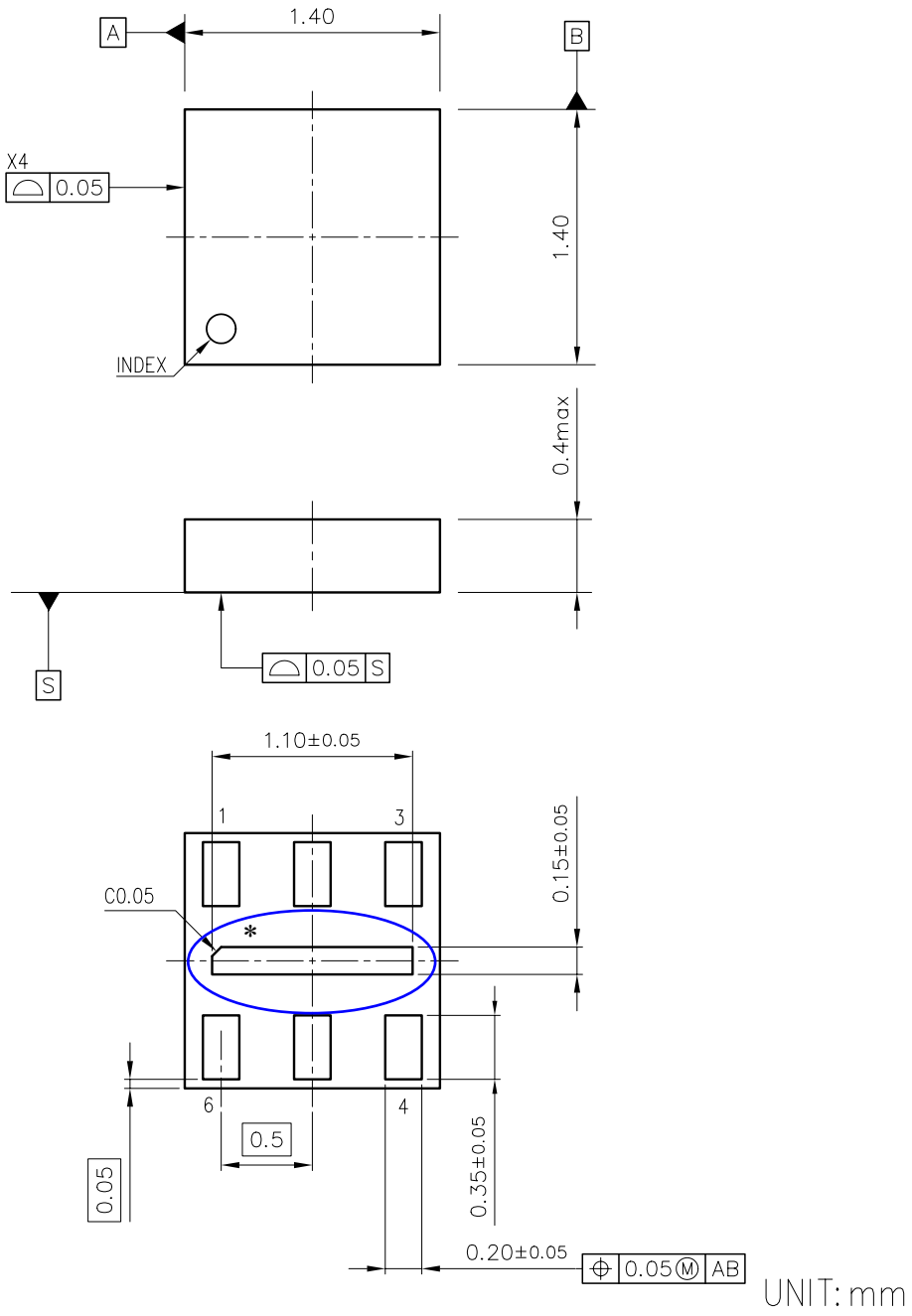
V_{SHORT}: Short protection voltage, refer to *"Electrical Characteristics"* for set voltages.
R3: External current sense resistance [Ω]
R_{SS}(on): external MOSFETs' total on-resistance [Ω]
V_{DD}: V_{DD} level at short mode. If V_{DD} goes down by the short current, the lowest level is V_{DD}.

Ex. 1
As the R_{SENSE}, in case that the 10 mΩ is selected as R3 and if the V_{DD} becomes 3.0 V, to detect short at 50 A with V_{SHORT} = 0.5 V, the R_{SS}(on) must be 32 mΩ or lower.

Ex. 2
As the R_{SENSE}, in case the 20 mΩ is selected as R3 and if the V_{DD} becomes 3.0 V, to detect short at 25 A with V_{SHORT} = 0.5 V, the R_{SS}(on) must be 64 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.

Ver. A



DFN(PLP)1414-6 Package Dimensions

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

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