Outline

The R5480 is a 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 R5480 can detect over-charge/discharge of Li+ one-cell and excess load current and charge current, further, include a short circuit protector for preventing large external short circuit current. The R5480 consists of four voltage detectors, a reference unit, a delay circuit, a short circuit detector, an oscillator, a counter, and a logic circuit.

When the R5480 detects over-charge or over-charge current, the output of COUT pin switches to "L" level, of the charger's negative pin level after the internal fixed delay time. When the R5480 detects over-discharge or excess discharge current, the output of DOUT pin switches to "L" level after the internal fixed delay time.

After detecting over-charge or excess charge current, the R5480 can be reset and the output of COUT becomes "H" after the charger is disconnected from the battery pack, and the cell voltage becomes lower than over-charge detector threshold.

However, depending on the characteristics of external components such as MOSFETs, release conditions may be not enough just removing a charger from the battery pack. In that case, a kind of load must be set to release the over-charge detect.

If a charger is continuously connected to the battery pack, even if the cell voltage becomes lower than over-charge detector threshold, over-charge state is not released.

After detecting over-discharge voltage, connect a charger to the battery pack, and when the battery supply voltage becomes higher than over-discharge detector threshold, the R5480 is released and the voltage of DOUT pin becomes "H". If the battery is discharged to 0V, recharge current is not acceptable. Once after detecting excess discharge-current or short circuit, the R5480 is released and DOUT level becomes "H" with detaching a battery pack from a load system. After detecting over-discharge, supply current is kept extremely low by halting internal circuits' operation.

When the output of COUT is "H", by setting the V- pin between -3.0V and the delay shortening mode voltage (Typ. -2.0V), the output delay can be shortened. Especially, the delay time of over charge detector can be reduced into approximately 1/100. Thus, testing time of protector circuit board can be reduced. Output type of COUT and DOUT is CMOS.

■ FEATURES

- Manufactured with High Voltage Tolerant Process ········Absolute Maximum Rating 30V
- Low supply current ···Supply current (At normal mode) TYP.4.0μA
  Standby current MAX 0.1μA
- High accuracy detector threshold··················Over-charge detector ±20mV
  Over-discharge detector ±35mV
  Excess discharge-current detector ±15%
  Excess charge-current detector ±15%
- Variety of detector threshold ·························Over-charge detector threshold 4.1V~4.5V step of 0.005V
  Over-discharge detector threshold 2.1V ~ 3.0V step of 0.005V
  Excess discharge-current threshold 0.030V ~ 0.048V step of 0.001V
  Excess charge-current threshold -0.030V~-0.020V step of 0.001V
- Internal fixed Output delay time ·····················Over-charge detector Output Delay 1.0s
  Over-discharge detector Output Delay 20ms
  Excess discharge-current detector Output Delay 12ms
  Excess charge-current detector Output Delay 16ms
  Short Circuit detector Output Delay 250μs
- Output Delay Time Shortening Function ······At C_{OUT} is "H", if V- level is set at –2.0V, 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.)

- Conditions for release over-charge detector………………... Latch type
- Conditions for release over-discharge detector……………. Latch type
- 0V-battery charge option ·································unacceptable
- Ultra 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

Absolute Maximum Ratings

Ta=25°C, Vss=0V

Item	Symbol	Ratings	Unit
Supply Voltage	V_{DD}	-0.3 to 12	V
Input Voltage			
V- pin Voltage	V-	V_{DD}-30 to V_{DD}+0.3	V
R_{SENS} pin Voltage	V_{RSENS}	Vss-0.3 to V_{DD}+0.3	V
Output Voltage			
C_{OUT} pin Voltage	V_{COUT}	V_{DD}-30 to V_{DD}+0.3	V
D_{OUT} pin Voltage	V_{DOUT}	Vss-0.3 to V_{DD}+0.3	V
Power Dissipation	P_D	150	mW
Operating Temperature	Ta	-40 to 85	°C
Storage Temperature	Tstg	-55 to 125	°C

*Note: Exposure to the condition exceeded Absolute Maximum Ratings may cause the permanent damages and affects the reliability and safety of both device and systems using the device. The functional operations cannot be guaranteed beyond specified values in the recommended conditions.

Electrical Characteristics

Unless otherwise provided, Ta=25°C

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Operating Input Voltage	VDD1	V_{DD}- Vss	1.5		5.0	V
Maximum Operating Voltage for Inhibition of Charger	Vnochg	Voltage Defined as V_{DD}-Vss, VDD-V-=4V	0.4	0.7	1.0	V
Over-charge Threshold Voltage	VDET1	R1=330Ω	VDET1 -0.020	VDET1	VDET1 +0.020	V
Output Delay of Over-charge	tVDET1	V_{DD}=3.6V→4.5V	0.7	1.0	1.3	s
Release Delay for VD1	tVREL1	V_{DD}=4V, V-=0V→1V	11	16	21	ms
Over-discharge Threshold	VDET2	Detect falling edge of supply voltage	VDET2 -0.035	VDET2	VDET2 +0.035	V
Output Delay of Over-discharge	tVDET2	V_{DD}=3.6V→2.0V	14	20	26	ms
Release Delay for VD2	tVREL2	V_{DD}=3V, V-=3V→0V	0.7	1.2	1.7	ms
Excess discharge-current threshold	VDET3	Detect rising edge of 'Rsens' pin voltage V- = V_{RSENS}	VDET3 ×0.85	VDET3	VDET3 ×1.15	V
Output delay of excess discharge-current	tVDET3	V_{DD}=3.0V,V_{RSENS}=0V to 0.4V V- = V_{RSENS}	8	12	16	ms
Output delay of release from excess discharge-current	tVREL3	V_{DD}=3.0V, V-=3V to 0V V- = V_{RSENS}	0.7	1.2	1.7	ms
Short Protection Voltage (R5480KxxxCG)	Vshort	V_{DD}=3.0V, V_{RSENS}=V-	0.41	0.50	0.59	V
Short Protection Voltage (R5480KxxxCL)	Vshort	V_{DD}=3.0V, V_{RSENS}=V-	0.135	0.18	0.225	V
Delay Time for Short Protection	tshort	V_{DD}=3.0V, V_{RSENS}=0V to 3V V- = V_{RSENS}	180	250	425	μs
Reset Resistance for Excess Current Protection	Rshort	V_{DD}=3.6V,V- =1.0V	20	45	70	kΩ
Excess charge-current threshold	VDET4	Detect falling edge of 'Rsens' pin voltage V- = V_{RSENS}	VDET4 ×0.85	VDET4	VDET4 ×1.15	V
Output delay of excess charge-current	tVDET4	V_{DD}=3.0V,V_{RSENS}=0Vto -0.3V V- = V_{RSENS}	11	16	21	ms
Output delay of release from excess charge-current	tVREL4	V_{DD}=3.0V, V-=-1V to 0V V- = V_{RSENS}	0.7	1.2	1.7	ms
Delay Time Shortening Mode Voltage	VDS	V_{DD}=3.6V	-2.6	-2.0	-1.4	V
Nch ON-Voltage of C_{OUT}	VoL1	Iol=50μA, V_{DD}=4.5V		0.4	0.5	V
Pch ON-Voltage of C_{OUT}	VoH1	Ioh=-50μA, V_{DD}=3.9V	3.4	3.7		V
Nch ON-Voltage of D_{OUT}	VoL2	Iol=50μA, V_{DD}=2.0V		0.2	0.5	V
Pch ON-Voltage of D_{OUT}	VoH2	Ioh=-50μA, V_{DD}=3.9V	3.4	3.7		V
Supply Current	IDD	V_{DD}=3.9V, V- =0V		4.0	8.0	μA
Standby Current	Istandby	V_{DD}=2.0V			0.1	μA

●: 'Note1' 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.

Electrical Characteristics

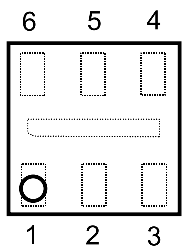
Ta=-20℃～+60℃

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Operating Input Voltage	VDD1	V_{DD}- Vss	1.5		5.0	V
Maximum Operating Voltage for Inhibition of Charger	Vnochg	Voltage Defined as V_{DD}-Vss, VDD-V-=4V	0.27	0.7	1.1	V
Over-charge Threshold Voltage	VDET1	R1=330Ω	VDET1 -0.025	VDET1	VDET1 +0.025	V
Output Delay of Over-charge	tVDET1	V_{DD}=3.6V→4.5V	0.67	1.0	1.55	s
Release Delay for VD1	tVREL1	V_{DD}=4V, V-=0V→1V	10.7	16	24.8	ms
Over-discharge Threshold	VDET2	Detect falling edge of supply voltage	VDET2 -0.040	VDET2	VDET2 +0.040	V
Output Delay of Over-discharge	tVDET2	V_{DD}=3.6V→2.0V	13.4	20	31	ms
Release Delay for VD2	tVREL2	V_{DD}=3V, V-=3V→0V	0.65	1.2	1.86	ms
Excess discharge-current threshold	VDET3	Detect rising edge of 'Rsens' pin voltage V- = V_{RSENS}	VDET3 ×0.83	VDET3	VDET3 ×1.17	V
Output delay of excess discharge-current	tVDET3	V_{DD}=3.0V,V_{RSENS}=0V to 0.4V V- = V_{RSENS}	7.5	12	18.6	ms
Output delay of release from excess discharge-current	tVREL3	V_{DD}=3.0V, V-=3V to 0V V- = V_{RSENS}	0.65	1.2	1.86	ms
Short Protection Voltage (R5480KxxxCG)	Vshort	V_{DD}=3.0V, V_{RSENS}=V-	0.40	0.50	0.60	V
Short Protection Voltage (R5480KxxxCL)	Vshort	V_{DD}=3.0V, V_{RSENS}=V-	0.130	0.18	0.230	V
Delay Time for Short Protection	tshort	V_{DD}=3.0V, V_{RSENS}=0V to 3V V- = V_{RSENS}	160	250	490	μs
Reset Resistance for Excess Current Protection	Rshort	V_{DD}=3.6V,V- =1.0V	17.3	45	73.3	kΩ
Excess charge-current threshold	VDET4	Detect falling edge of 'Rsens' pin voltage V- = V_{RSENS}	VDET4 ×0.83	VDET4	VDET4 ×1.17	V
Output delay of excess charge-current	tVDET4	V_{DD}=3.0V,V_{RSENS}=0Vto -0.3V V- = V_{RSENS}	10.7	16	24.8	ms
Output delay of release from excess charge-current	tVREL4	V_{DD}=3.0V, V-=-1V to 0V V- = V_{RSENS}	0.65	1.2	1.86	ms
Delay Time Shortening Mode Voltage	VDS	V_{DD}=3.6V	-2.7	-2.0	-1.2	V
Nch ON-Voltage of C_{OUT}	VoL1	Iol=50μA, V_{DD}=4.5V		0.4	0.5	V
Pch ON-Voltage of C_{OUT}	VoH1	Ioh=-50μA, V_{DD}=3.9V	3.4	3.7		V
Nch ON-Voltage of D_{OUT}	VoL2	Iol=50μA, V_{DD}=2.0V		0.2	0.5	V
Pch ON-Voltage of D_{OUT}	VoH2	Ioh=-50μA, V_{DD}=3.9V	3.4	3.7		V
Supply Current	IDD	V_{DD}=3.9V, V- =0V		4.0	8.7	μA
Standby Current	Istandby	V_{DD}=2.0V			0.12	μA

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

PIN CONFIGURATIONS

R5480K : DFN(PLP)1414-6



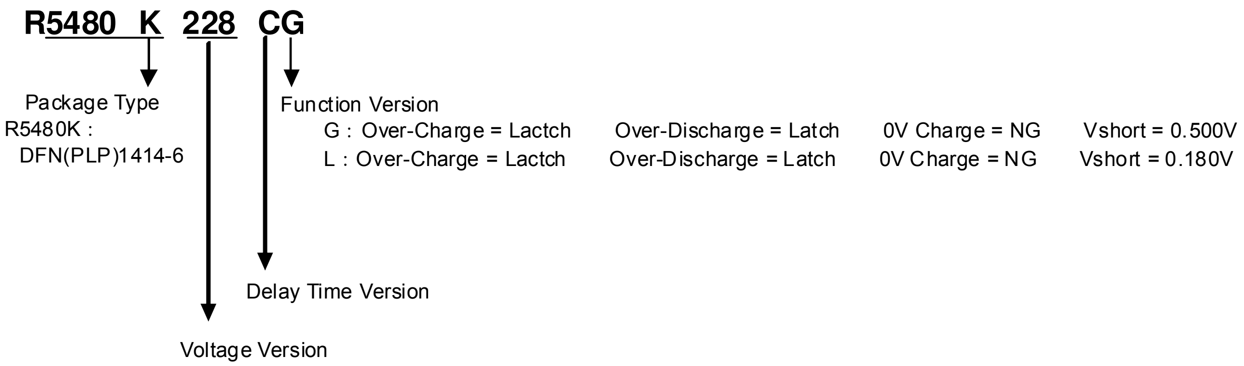
PIN DESCRIPTION

Pin No.	Symbol	Description
1	V_{SS}	Vss pin. Ground pin for the IC
2	V_{DD}	Power supply pin, the substrate voltage level of the IC.
3	RSENS	Input of overcurrent detection
4	V-	Pin for charger negative input
5	C_{OUT}	Output of over-charge detection, CMOS output
6	D_{OUT}	Output of over-discharge detection, CMOS output

■ SELECTION GUIDE

In the R5480 Series, input threshold of over-charge, over-discharge, excess discharge current, and the package and taping can be designated.

Part Number is designated as follows:



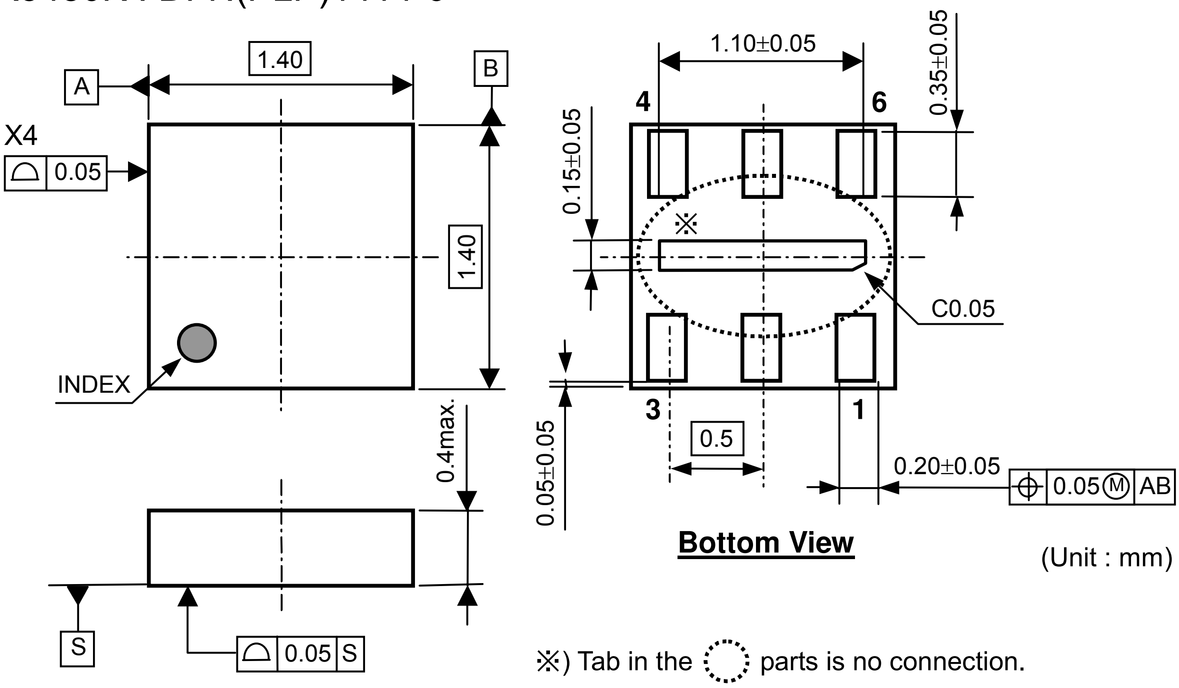
Code	Return from Over-Charge	Return from Over-Discharge	tVdet1 (s)	tVdet2 (ms)	tVdet3 (ms)	tVdet4 (ms)	tShort (μs)	0V Charge
R5480x xxx CG	Latch	Latch	1	20	12	16	250	NG
R5480x xxx CL	Latch	Latch	1	20	12	16	250	NG

R5480K Series : DFN(PLP)1414-6

Code	VDET1 (V)	VREL1 (V)	VDET2 (V)	VREL2 (V)	VDET3 (V)	VDET4 (V)	Vshort (V)	tVdet1 (s)	tVdet2 (ms)	tVdet3 (ms)	tVdet4 (ms)	tShort (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
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

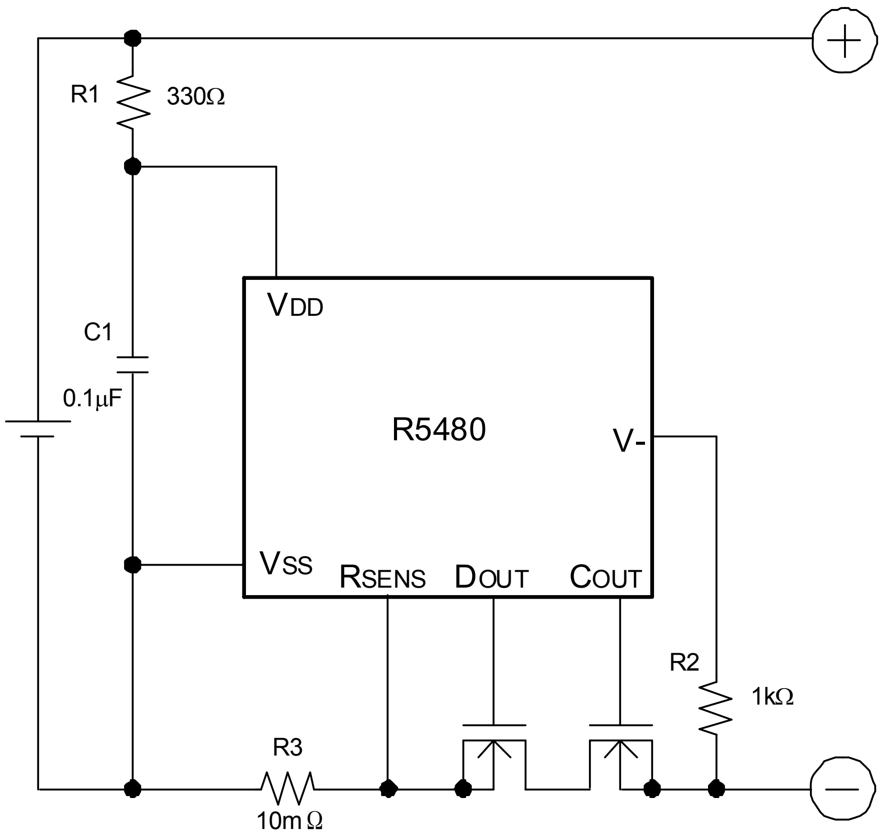
Package Dimensions

R5480K : DFN(PLP)1414-6



※) Tab in the parts is no connection.

Technical Notes



*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 R5480.
Further, to stabilize the operation of R5480, use the C1 with the value of 0.01μF or more.

*R1 and R2 can operate as a current limit against setting cell reverse direction or applying excess charge voltage to the R5480. While small value of R1 and R2 may cause over power dissipation rating of the R5480, 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.
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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.

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 Vshort and R3, the next formula must be true, otherwise, the short current limit becomes (VDD^*-0.9)/(R3+Rss(on))

$$\frac{VDD^* - 0.9}{R3 + Rss(on)} \geq \frac{Vshort}{R3}$$

*Vshort = 0.5V (CG version) , 0.18V(CL version)
*R3 = External current sense Resistance(Ω)
*Rss(on) = external MOSFETs' total ON Resistance(Ω)
*VDD^* = VDD level at short mode. If VDD goes down by the short current, the lowest level is VDD^*.

Notes: in case of the short mode is specified at short current determined by the relation between R3 and Vshort value,

ex. 1
*As the Rsense, in case that the 10mΩ is selected as R3 and if the VDD^* becomes 3.0V, to detect short at 50A with Vshort=0.5V, the Rss(on) must be 32mΩ or lower.
Otherwise, according to the Rss(on), short current limit is lower than expected.

ex. 2
*As the Rsense, in case the 20mΩ is selected as R3 and if the VDD^* becomes 3.0V, to detect short at 25A with Vshort=0.5V, the Rss(on) must be 64mΩ or lower.

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