1-Cell Li-Ion Battery Protection IC

NO.EA-323-181116

OUTLINE

The R5472 is 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 R5472 can detect over-charge/discharge of Li+ one-cell and excess load current, further include a short circuit protector for preventing large external short circuit current and the excess charge-current. The R5472 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 R5472 detects over-charge or over-charge current, the output of COUT pin switches to “L” level, that is, the charger’s negative pin level after the internal fixed delay time. When the R5472 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, theR5472 can be reset and the output of COUT becomes “H” when a 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 R5472 is released and the voltage of DOUT pin becomes “H”. If the battery is discharged lower than maximum voltage for inhibition of charger, recharge current is not acceptable. Once after detecting excess discharge-current or short circuit, the R5472 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 at equal or lower than 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 1/110. Thus, testing time of protector circuit board can be reduced. Output type of COUT and DOUT is CMOS.

NO.EA-323-181116

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 ····· ±10mV
  - Excess charge-current detector ····· ±10mV
- Variety of detector threshold
  - Over-charge detector threshold ····· 4.1V to 4.405V in step of 0.005V
  - Over-discharge detector threshold ····· 2.1V to 3.0V in step of 0.050V
  - Excess discharge-current threshold ····· 0.050V to 0.12V in step of 0.005V
  - Excess charge-current threshold ····· -0.050V to -0.12V in step of 0.005V
- 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 ····· R5472L : DFN1414-6 ,
  R5472K : 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 input threshold of over-charge, over-discharge, excess discharge current, and the package and taping can be designated.

Selection Guide

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R5472Lxxx$∗-TR	DFN1414-6	5,000 pcs	Yes	Yes
R5472Kxxx$∗-TR	DFN(PLP)1414-6	5,000 pcs	Yes	Yes

xxx: Set Voltage Code

Refer to *R5472x Code List*.

$: Delay Time Version

Version	t_{VDET1} (s)	t_{VDET2} (ms)	t_{VDET3} (ms)	t_{VDET4} (ms)	t_{SHORT} (µs)
C	1	20	12	16	250

∗: Function Version

Version	Return from Over-Charge	Return from Over-Discharge	0-V Charge
G	Latch	Latch	NG

Product Code List

R5472LCode List

Code	Set Voltage [V]						Delay Time					Function
	V_{DET1}	V_{REL1}	V_{DET2}	V_{REL2}	V_{DET3}	V_{DET4}	t_{VDET1} (s)	t_{VDET2} (ms)	t_{VDET3} (ms)	t_{VDET4} (ms)	t_{SHORT} (µs)	0V Charge
R5472L206CG	4.280	-	2.400	-	0.080	-0.060	1	20	12	16	250	NG
R5472L225CG	4.280	-	2.400	-	0.100	-0.080	1	20	12	16	250	NG
R5472L230CG	4.280	-	2.800	-	0.100	-0.080	1	20	12	16	250	NG
R5472L231CG	4.280	-	2.800	-	0.080	-0.060	1	20	12	16	250	NG

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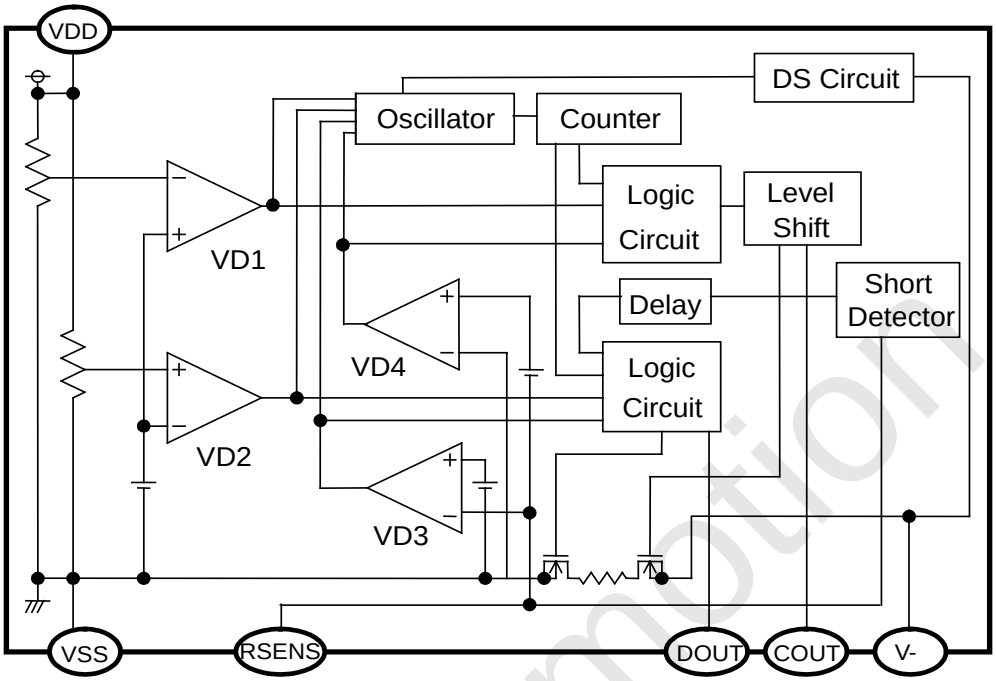
R5472KCode List

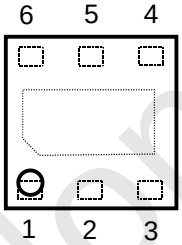
Code	Set Voltage [V]						Delay Time					Function
	V_{DET1}	V_{REL1}	V_{DET2}	V_{REL2}	V_{DET3}	V_{DET4}	t_{VDET1} (s)	t_{VDET2} (ms)	t_{VDET3} (ms)	t_{VDET4} (ms)	t_{SHORT} (µs)	0V Charge
R5472K206CG	4.280	-	2.400	-	0.080	-0.060	1	20	12	16	250	NG
R5472K231CG	4.280	-	2.800	-	0.080	-0.060	1	20	12	16	250	NG
R5472K234CG	4.405	-	2.400	-	0.080	-0.050	1	20	12	16	250	NG
R5472K236CG	4.230	-	2.800	-	0.080	-0.060	1	20	12	16	250	NG
R5472K246CG	4.405	-	2.800	-	0.080	-0.060	1	20	12	16	250	NG
R5472K251CG	4.230	-	3.000	-	0.080	-0.060	1	20	12	16	250	NG
R5472K252CG	4.280	-	3.000	-	0.080	-0.060	1	20	12	16	250	NG

BLOCK DIAGRAM

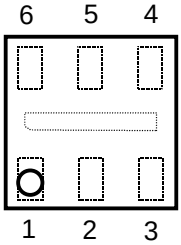


R5472x Block Diagram

PIN DESCRIPTIONS



R5472L (DFN1414-6) Pin Configuration



R5472K (DFN(PLP)1414-6) Pin Configuration

R5472x Pin Description

Pin No.		Symbol	Description
R5472L	R5472K		
1	1	VSS	Vss pin. Ground pin for the IC
2	2	VDD	Power supply pin, the substrate voltage level of the IC.
3	3	RSENS	Input of overcurrent detection
4	4	V-	Pin for charger negative input
5	5	COUT	Output of over-charge detection, CMOS output
6	6	DOUT	Output of over-discharge detection, CMOS output

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.

ELECTRICAL CHARACTERISTICS

R5472x Electrical Characteristics Unless otherwise provided, Ta = 25°C

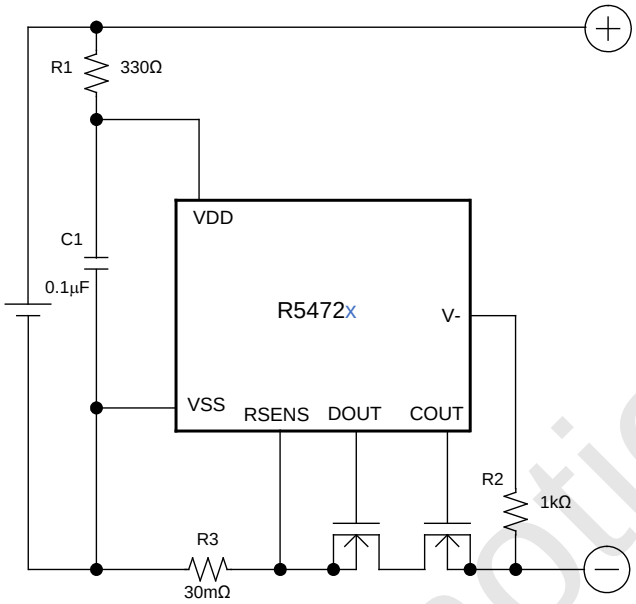
Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{NOCHG}	Maximum Operating Voltage for Inhibition of Charger	Voltage Defined as V_{DD}-Vss, VDD-V- = 4V	0.4	0.7	1.0	V
V_{DET1}	Over-charge Threshold Voltage	R1=330Ω	V_{DET1} -0.020	V_{DET1}	V_{DET1} +0.020	V
t_{VDET1}	Output Delay of Over-charge	V_{DD}=3.6V→4.4V	0.7	1.0	1.3	s
t_{VREL1}	Release Delay for VD1	V_{DD}=4V, V- = 0V→1V	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}=3.6V→2.0V	14	20	26	ms
t_{VREL2}	Release Delay for VD2	V_{DD}=3V, V-=3V→0V	0.7	1.2	1.7	ms
V_{DET3}	Excess discharge-current threshold	Detect rising edge of 'RSENS' pin voltage V- = V_{RSENS}	V_{DET3} -0.010	V_{DET3}	V_{DET3} +0.010	V
t_{VDET3}	Output delay of excess discharge-current	V_{DD}=3.0V, V_{RSENS}= 0V to 0.4V V- = V_{RSENS}	8	12	16	ms
t_{VREL3}	Output delay of release from excess discharge-current	V_{DD}=3.0V, V-=3V to 0V V- = V_{RSENS}	0.7	1.2	1.7	ms
V_{SHORT}	Short Protection Voltage	V_{DD}=3.0V, V_{RSENS}=V-	0.41	0.5	0.59	V
t_{SHORT}	Delay Time for Short Protection	V_{DD}=3.0V, V_{RSENS}=0V to 3V V- = V_{RSENS}	180	250	425	µs
R_{SHORT}	Reset Resistance for Excess Current Protection	V_{DD}=3.6V,V- =1.0V	20	45	70	kΩ
V_{DET4}	Excess charge-current threshold	Detect falling edge of 'RSENS' pin voltage V- = V_{RSENS}	V_{DET4} +0.010	V_{DET4}	V_{DET4} -0.010	V
t_{VDET4}	Output delay of excess charge-current	V_{DD}=3.0V, V_{RSENS}=0V to -0.3V V- = V_{RSENS}	11	16	21	ms
t_{VREL4}	Output delay of release from excess charge-current	V_{DD}=3.0V, V- = -1V to 0V V- = V_{RSENS}	0.7	1.2	1.7	ms
V_{DS}	Delay Time Shortening Mode Voltage	V_{DD}=3.6V	-2.6	-2.0	-1.4	V
V_{OL1}	Nch ON-Voltage of C_{OUT}	Iol=50µA, V_{DD}=4.5V		0.4	0.5	V
V_{OH1}	Pch ON-Voltage of C_{OUT}	Ioh=-50µA, V_{DD}=3.9V	3.4	3.7		V
V_{OL2}	Nch ON-Voltage of D_{OUT}	Iol=50µA, V_{DD}=2.0V		0.2	0.5	V
V_{OH2}	Pch ON-Voltage of D_{OUT}	Ioh=-50µA, V_{DD}=3.9V	3.4	3.7		V
I_{DD}	Supply Current	V_{DD}=3.9V, V- =0V		4.0	8	µA
Istandby	Standby Current	V_{DD}=2.0V			0.1	µA

R5472x 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 V_{DD}-Vss, VDD-V-=4V	0.27	0.7	1.1	V
V_{DET1}	Over-charge Threshold Voltage	R1=330Ω	V_{DET1} -0.025	V_{DET1}	V_{DET1} +0.025	V
t_{VDET1}	Output Delay of Over-charge	V_{DD}=3.6V→4.4V	0.67	1.0	1.55	s
t_{VREL1}	Release Delay for VD1	V_{DD}=4V, V-=0V→1V	10.7	16	24.8	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}=3.6V→2.0V	13.4	20	31	ms
t_{VREL2}	Release Delay for VD2	V_{DD}=3V, V-=3V→0V	0.65	1.2	1.86	ms
V_{DET3}	Excess discharge-current threshold	Detect rising edge of 'RSENS' pin voltage V- = V_{RSENS}	V_{DET3} -0.013	V_{DET3}	V_{DET3} +0.013	V
t_{VDET3}	Output delay of excess discharge-current	V_{DD}=3.0V,V_{RSENS}=0V to 0.4V V- = V_{RSENS}	7.5	12	18.6	ms
t_{VREL3}	Output delay of release from excess discharge-current	V_{DD}=3.0V, V-=3V to 0V V- = V_{RSENS}	0.65	1.2	1.86	ms
V_{SHORT}	Short Protection Voltage	V_{DD}=3.0V, V_{RSENS}=V-	0.4	0.5	0.6	V
t_{SHORT}	Delay Time for Short Protection	V_{DD}=3.0V, V_{RSENS}=0V to 3V V- = V_{RSENS}	160	250	490	µs
R_{SHORT}	Reset Resistance for Excess Current Protection	V_{DD}=3.6V,V- =1.0V	17.3	45	73.3	kΩ
V_{DET4}	Excess charge-current threshold	Detect falling edge of 'RSENS' pin voltage V- = V_{RSENS}	V_{DET4} -0.015	V_{DET4}	V_{DET4} +0.015	V
t_{VDET4}	Output delay of excess charge-current	V_{DD}=3.0V,V_{RSENS}=0Vto -0.3V V- = V_{RSENS}	10.7	16	24.8	ms
t_{VREL4}	Output delay of release from excess charge-current	V_{DD}=3.0V, V-=-1V to 0V V- = V_{RSENS}	0.65	1.2	1.86	ms
V_{DS}	Delay Time Shortening Mode Voltage	V_{DD}=3.6V	-2.7	-2.0	-1.2	V
V_{OL1}	Nch ON-Voltage of C_{OUT}	Iol=50µA, V_{DD}=4.5V		0.4	0.5	V
V_{OH1}	Pch ON-Voltage of C_{OUT}	Ioh=-50µA, V_{DD}=3.9V	3.4	3.7		V
V_{OL2}	Nch ON-Voltage of D_{OUT}	Iol=50µA, V_{DD}=2.0V		0.2	0.5	V
V_{OH2}	Pch ON-Voltage of D_{OUT}	Ioh=-50µA, V_{DD}=3.9V	3.4	3.7		V
I_{DD}	Supply Current	V_{DD}=3.9V, V- =0V		4.0	8.7	µA
Istandby	Standby Current	V_{DD}=2.0V			0.12	µA

Note: All of this specification is guaranteed by design, not mass production tested.

APPLICATION INFORMATION



R5472x Typical Application Circuit

Cautions in selecting external components

- R1 and C1 stabilize a supply voltage to the R5472. A recommended R1 value is less than 1kΩ. A large value of R1 makes detection voltage shift higher because of conduction current flown in the R5472. Further, to stabilize the operation of R5472, 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 R5472, battery pack. While small value of R1 and R2 may cause over power dissipation rating of the R5472, therefore a total of "R1+R2" should be 1kΩ or more. Besides, if 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 resistor to sense overdischarge or overcharge current. Recommended R3 value is 30mΩ.
- The typical application circuit diagram is just an example. This circuit performance largely depends on the PCB layout and external components. In the actual application, fully evaluation is necessary.
- Over-voltage and the over current beyond the absolute maximum rating should not be forced to the protection IC and external components.
- If positive terminal and negative terminal of the battery pack short, even though the short protection circuit is built in the IC, during the delay time until detecting the shortcircuit, 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

Please select external MOSFET and sense resistor by the following expression.

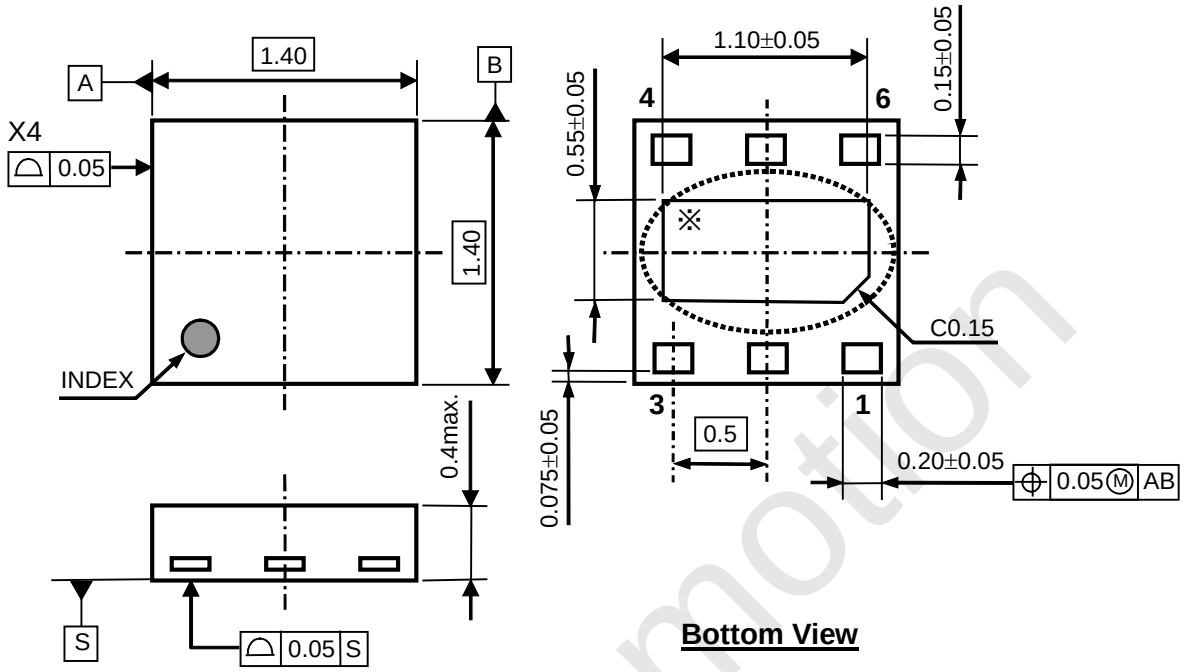
$$\frac{1.3}{(R3 + MOSFETsRon)} \geq \frac{vshort}{R3}$$

V_{SHORT} = 0.5(V)
R3 = External current sense Resistance (Ω)
MOSFETsRon = external MOSFET ON Resistance (Ω)

Notes:
ex.
*As the Rsense, in case the 10mΩ is selected, to detect short at 50A with vshort=0.5V,
The on resistance of the external MOSFET must be 15mΩ or lower.
Otherwise, according to the Ron of the MOSFET, short current limit is lower than expected.

ex.
*As the Rsense, in case the 20mΩ is selected, to detect short at 25A with vshort=0.5V,
The on resistance of the external MOSFET must be 30mΩ or lower.

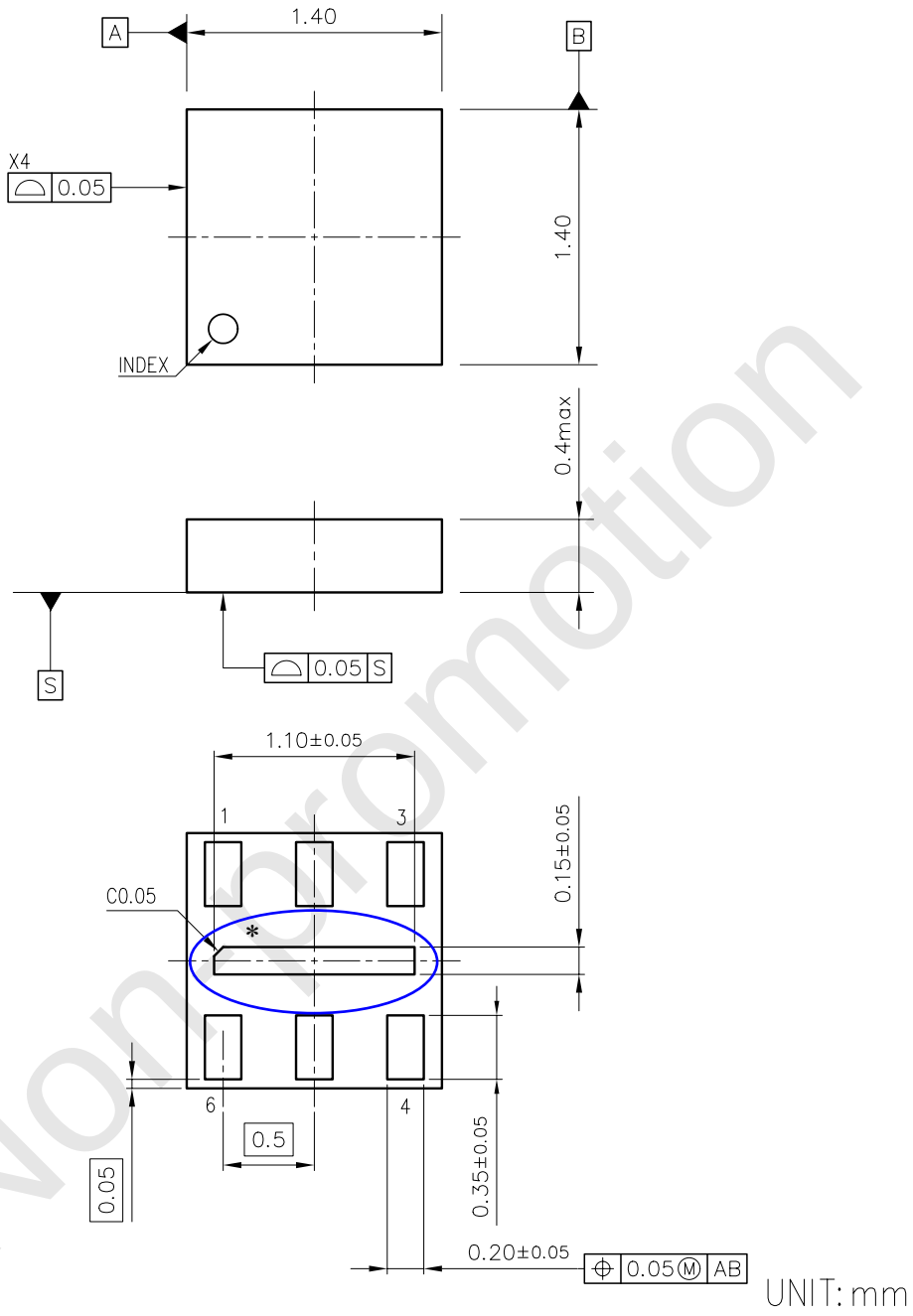
ex.
*As the Rsense, in case the 30mΩ is selected, to detect short at 16.6A with vshort=0.5V,
The on resistance of the external MOSFETmust be 45mΩ or lower.



HSOP-18 Package Dimensions (Unit: mm)

* The tab on the bottom of the package shown by blue circle is a substrate potential (GND/V_{DD}). Do not connect to other wires or land patterns.

Ver. A



DFN(PLP)1414-6 Package Dimensions

* The tab on the bottom of the package shown by blue circle is a substrate potential (VDD). It is recommended that this tab be connected to the VDD pin on the board but it is possible to leave the tab floating.

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