Li-Ion BATTERY PROTECTOR
R5422NxxxC/xxxE series

OUTLINE

The R5422NxxxC/E Series are protection ICs for over-charge/discharge of rechargeable one-cell Lithium-ion (Li+) excess load current, further include a short circuit protector for preventing large external short circuit current.
Each of these ICs is composed of three voltage detectors, a reference unit, a delay circuit, a short circuit protector, and a logic circuit. When charging voltage crosses the detector threshold from a low value to a value higher than V_{DET1}, the output of C_{OUT} pin, the output of over-charge detector/VD1, switches to low level, charger's negative pin level after the delay time by setting an external capacitor. After detecting over-charge the VD1 can be reset and the output of C_{OUT} becomes high when the V_{DD} voltage is coming down to a level lower than "V_{REL1}", or when a kind of loading is connected to V_{DD} after a charger is disconnected from the battery pack while the V_{DD} level is in between "V_{DET1}" and "V_{REL1}" in the R5422NxxxC/E version.
The output of D_{OUT} pin, the output of over-discharge detector/VD2, switches to low level after internally fixed delay time passed, when discharging voltage crosses the detector threshold from a high value to a value lower than V_{DET2}.
After R5422NxxxC/E Series detect the over-discharge voltage, connect a charger to the battery pack, and when the battery supply voltage becomes higher than the over-discharge detector threshold, VD2 is released and the voltage of D_{OUT} becomes "H" level.

An excess load current can be sensed and cut off after internally fixed delay time passed through the built in excess current detector, VD3, with D_{OUT} being enabled to low level. Once after detecting excess current, the VD3 is released and D_{OUT} level switches to high by detaching a battery pack from a load system.
Further, short circuit protector makes D_{OUT} level to low immediately with external short circuit current and removing external short circuit leads D_{OUT} level to high. After detecting over-discharge, supply current will be kept extremely low by halt some internal circuits operation. Output type of C_{OUT} and D_{OUT} is CMOS. 6-pin, SOT23-6 is available.

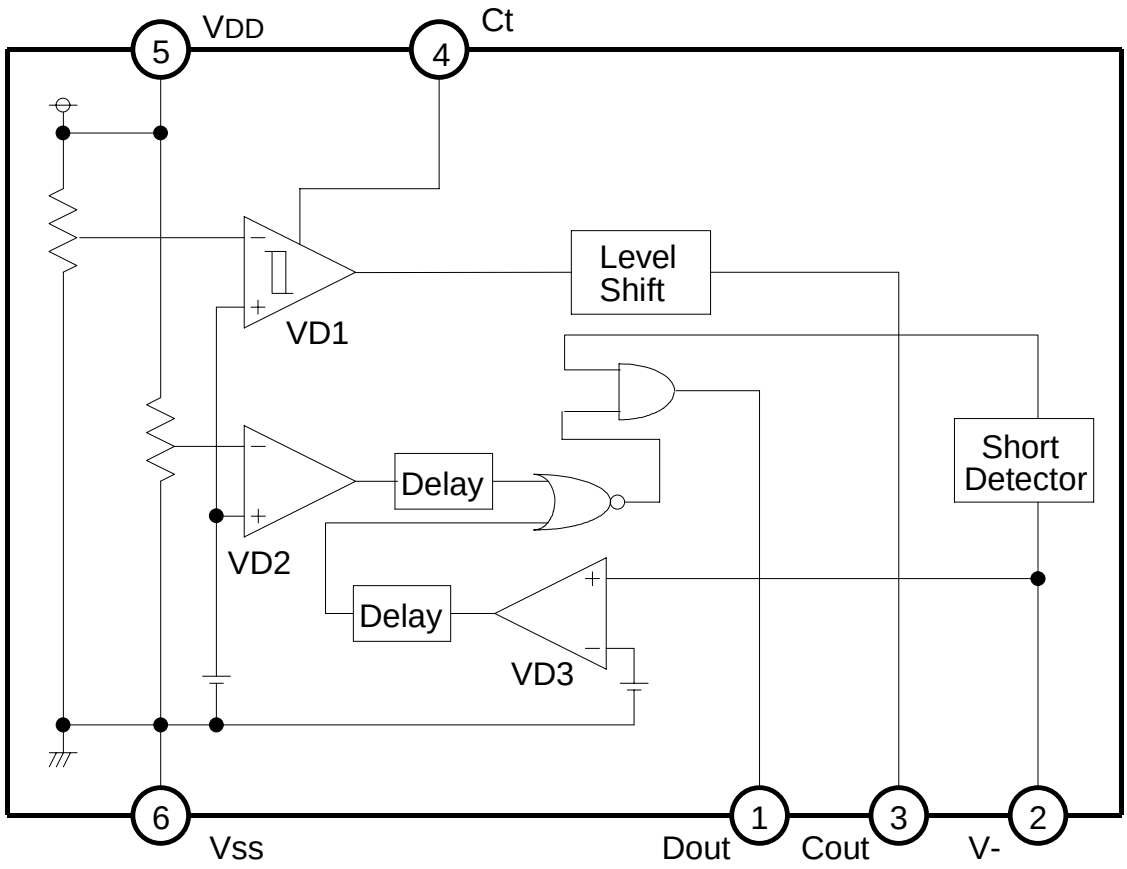
FEATURES

- High Voltage Process Technology — Absolute Maximum Rating of Voltage level between V_{DD}-V- 28v
- Low supply current
  - Supply current — Typ. 6.0µA
  - Standby current (detecting over-discharge) — Typ. 0.1µA
- High accuracy detector threshold
  - Over-charge detector (Topt=25°C) — ±25mV
  - (Topt=0 to 50°C) — ±30 mV
  - Over-discharge detector — ±2.5%
  - Excess current detector — ±20mV
- Variety of detector threshold
  - Over-charge detector threshold — 4.0V - 4.5V step of 0.01V
  - Over-discharge detector threshold — 2.0V - 3.0V step of 0.01V
- Built-in protection circuit
  - Excess current protection — 0.05V - 0.4V step of 0.01V
- Output delay of over-charge — Time delay at C=0.01µF tV_{DET1}=75ms, tV_{REL1}=20ms
- Output delay of over-discharge — Internally fixed TYP. 17ms
- Output delay of excess-current — Internally fixed TYP. 10ms
- 2 Over-current modes — Excess Current Mode / Short Mode
- Charging Available / non-available at 0V Cell
  - Acceptable of 0V Cell — C version
  - Non-acceptable of 0V Cell — E version
- Small package — SOT-23-6 / 6-pin

APPLICATIONS

- Li+ one-cell protector for battery pack

■ BLOCK DIAGRAM



■ SELECTION GUIDE

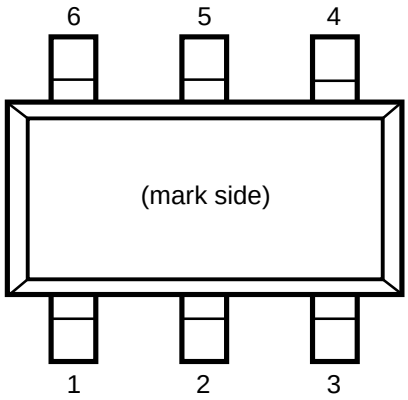
In the R5422Nxxxx Series, three of the input threshold for over-charge, over-discharge and excess current detectors can be designated.

Part Number is designated as follows:

R5422N XXXX-XX ←Part Number
↑ ↑ ↑
a b c

Code	Description
a	Serial Number for the R5422N Series designating input threshold for over-charge, over-discharge and excess current detectors as well as hysteresis range for over-charge detector.
b	Designation of version symbols
c	Taping Type: TR (refer to Taping Specification)

■ PIN CONFIGURATION



■ PIN DESCRIPTION

Pin No.	Symbol	Pin description
1	D_{OUT}	Output of over-discharge detection, CMOS output
2	V-	Pin for charger negative input
3	C_{OUT}	Output of over-charge detection, CMOS output
4	Ct	Pin for external capacitor setting output delay of VD1
5	V_{DD}	Power supply(Substrate voltage level of the IC)
6	V_{SS}	Ground(Ground pin of the IC)

■ ABSOLUTE MAXIMUM RATINGS

V_{SS}=0V

Symbol	Item	Ratings	Unit
V_{DD}	Supply voltage	-0.3 to 12	V
V- VCt	Input Voltage V - pin Ct pin	 V_{DD} -28 to V_{DD} +0.3 V_{SS} -0.3 to V_{DD} +0.3	 V V
VC$_{OUT}$ VD$_{OUT}$	Output voltage C$_{OUT}$ pin D$_{OUT}$ pin	 V_{DD} -28 to V_{DD} +0.3 V_{SS} -0.3 to V_{DD} +0.3	 V V
P_D	Power dissipation	150	mW
Topt	Operating temperature range	-40 to 85	°C
Tstg	Storage temperature range	-55 to 125	°C

ABSOLUTE MAXIMUM RATINGS

Absolute Maximum ratings are threshold limit values that must not be exceeded ever for an instant under any conditions. Moreover, such values for any two items must not be reached simultaneously. Operation above these absolute maximum ratings may cause degradation or permanent damage to the device. These are stress ratings only and do not necessarily imply functional operation below these limits.

■ ELECTRICAL CHARACTERISTIC

● R5422N111C

Unless otherwise provided, Topt=25°C

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V_{DD1}	Operating input voltage	Voltage defined as V_{DD} - V_{SS}	1.5		10	V
Vst	Minimum operating Voltage for 0V charging	Voltage defined as V_{DD} - V- , V_{DD} - V_{SS}=0V			1.2	V
V_{DET1}	Over-charge threshold	R1=330Ω(Topt=25°C) R1=330Ω (Topt=0 to 50°C)*Note	4.225 4.220	4.250 4.250	4.275 4.280	V V
V_{REL1}	Release voltage for over-charge detection		4.000	4.050	4.100	V
tV_{DET1}	Output delay of over-Charge	C=0.01µF, V_{DD}=3.6V to 4.3V	60	75	90	ms
tV_{REL1}	Output delay of Release from Over-charge	C=0.01µF, V_{DD}=4.3V to 4.1V	15	20	25	ms
V_{DET2}	Over-discharge threshold	Detect falling edge of supply voltage	2.437	2.500	2.563	V
tV_{DET2}	Output delay of over-Discharge	V_{DD}=3.6V to 2.4V	12	17	22	ms
V_{DET3}	Excess current threshold	Detect rising edge of 'V-' pin voltage	0.18	0.20	0.22	V
tV_{DET3}	Output delay of excess Current		7	10	13	ms
Vshort	Short protection voltage	V_{DD}=3.0V	V_{DD}-1.2	V_{DD}-0.9	V_{DD}-0.6	V
tshort	Output Delay of Short protection	V_{DD}=3.0V		5	50	µs
Rshort	Reset resistance for Excess current protection	V_{DD}=3.6V, V- =1.0V	37	75	113	kΩ
Vol1	Nch ON voltage of C_{OUT}	Iol=40µA, V_{DD}=4.4V		0.3	0.5	V
Voh1	Pch ON voltage of C_{OUT}	Ioh=-40µA, V_{DD}=3.9V	3.4	3.75		V
Vol2	Nch ON voltage of D_{OUT}	Iol=40µA, V_{DD}=2.2V		0.2	0.5	V
Voh2	Pch ON voltage of D_{OUT}	Ioh=-40µA, V_{DD}=3.9V	3.4	3.7		V
I_{DD}	Supply current	V_{DD}=3.9V, V- =0V		6.0	10.0	µA
Istandby	Standby current	V_{DD}=2.0V			0.1	µA

*Note: 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 production tested.

● R5422N112C

Unless otherwise provided, Topt=25°C

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V_{DD1}	Operating input voltage	Voltage defined as V_{DD} - V_{SS}	1.5		10	V
Vst	Minimum operating Voltage for 0V charging	Voltage defined as V_{DD} - V- , V_{DD} - V_{SS}=0V			1.2	V
V_{DET1}	Over-charge threshold	R1=330Ω(Topt=25°C) R1=330Ω (Topt=0 to 50°C)*Note	4.325 4.320	4.350 4.350	4.375 4.380	V V
V_{REL1}	Release voltage for over-charge detection		4.100	4.150	4.200	V
tV_{DET1}	Output delay of over-Charge	C=0.01µF, V_{DD}=3.6V to 4.4V	61	77	93	ms
tV_{REL1}	Output delay of Release from Over-charge	C=0.01µF, V_{DD}=4.4V to 4.1V	15	20	25	ms
V_{DET2}	Over-discharge threshold	Detect falling edge of supply Voltage	2.437	2.500	2.563	V
tV_{DET2}	Output delay of over-Discharge	V_{DD}=3.6V to 2.4V	12	17	22	ms
V_{DET3}	Excess current threshold	Detect rising edge of 'V-' pin Voltage	0.18	0.20	0.22	V
tV_{DET3}	Output delay of excess Current		7	10	13	ms
Vshort	Short protection voltage	V_{DD}=3.0V	V_{DD}-1.2	V_{DD}-0.9	V_{DD}-0.6	V
tshort	Output Delay of Short protection	V_{DD}=3.0V		5	50	µs
Rshort	Reset resistance for excess current protection	V_{DD}=3.6V, V- =1.0V	37	75	113	kΩ
Vol1	Nch ON voltage of C_{OUT}	Iol=40µA, V_{DD}=4.4V		0.3	0.5	V
Voh1	Pch ON voltage of C_{OUT}	Ioh=-40µA, V_{DD}=3.9V	3.40	3.75		V
Vol2	Nch ON voltage of D_{OUT}	Iol=40µA, V_{DD}=2.2V		0.2	0.5	V
Voh2	Pch ON voltage of D_{OUT}	Ioh=-40µA, V_{DD}=3.9V	3.4	3.7		V
I_{DD}	Supply current	V_{DD}=3.9V,V- =0V		6.0	10.0	µA
Istandby	Standby current	V_{DD}=2.0V			0.1	µA

*Note: 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 production tested.

● R5422N111E

Unless otherwise provided, Topt=25°C

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V_{DD1}	Operating input voltage	Voltage defined as V_{DD} - V_{SS}	1.5		10	V
Vnochg	Maximum Voltage for disable of 0V charging	Voltage defined as V_{DD} - V_{SS} , V_{DD} – V-=4V	0.5	0.8		V
V_{DET1}	Over-charge threshold	R1=330Ω(Topt=25°C) R1=330Ω (Topt=0 to 50°C)*Note	4.225 4.220	4.250 4.250	4.275 4.280	V V
V_{REL1}	Release voltage for over-charge detection		4.000	4.050	4.100	V
tV_{DET1}	Output delay of over-Charge	C=0.01µF, V_{DD}=3.6V to 4.3V	60	75	90	ms
tV_{REL1}	Output delay of Release from Over-charge	C=0.01µF, V_{DD}=4.3V to 4.1V	15	20	25	ms
V_{DET2}	Over-discharge threshold	Detect falling edge of supply Voltage	2.437	2.500	2.563	V
tV_{DET2}	Output delay of over-Discharge	V_{DD}=3.6V to 2.4V	12	17	22	ms
V_{DET3}	Excess current threshold	Detect rising edge of 'V-' pin Voltage	0.18	0.20	0.22	V
tV_{DET3}	Output delay of excess Current		7	10	13	ms
Vshort	Short protection voltage	V_{DD}=3.0V	V_{DD}-1.2	V_{DD}-0.9	V_{DD}-0.6	V
tshort	Output Delay of Short protection	V_{DD}=3.0V		5	50	µs
Rshort	Reset resistance for excess current protection	V_{DD}=3.6V, V- =1.0V	37	75	113	kΩ
Vol1	Nch ON voltage of C_{OUT}	Iol=40µA, V_{DD}=4.4V		0.3	0.5	V
Voh1	Pch ON voltage of C_{OUT}	Ioh=-40µA, V_{DD}=3.9V	3.4	3.75		V
Vol2	Nch ON voltage of D_{OUT}	Iol=40µA, V_{DD}=2.2V		0.2	0.5	V
Voh2	Pch ON voltage of D_{OUT}	Ioh=-40µA, V_{DD}=3.9V	3.4	3.7		V
I_{DD}	Supply current	V_{DD}=3.9V,V- =0V		6.0	10.0	µA
Istandby	Standby current	V_{DD}=2.0V			0.1	µA

*Note: 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 production tested.

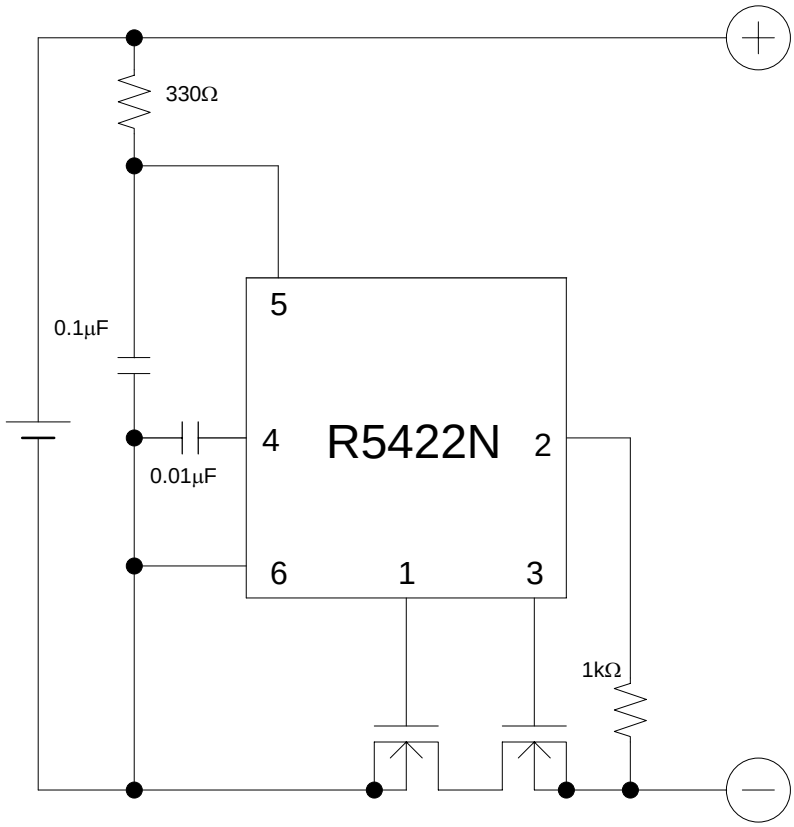
● R5422N112E

Unless otherwise provided, Topt=25°C

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V_{DD1}	Operating input voltage	Voltage defined as V_{DD} - V_{SS}	1.5		10	V
Vnochg	Maximum Voltage for disable of 0V charging	Voltage defined as V_{DD} - V_{SS} , V_{DD} – V-=4V	0.5	0.8		V
V_{DET1}	Over-charge threshold	R1=330Ω(Topt=25°C) R1=330Ω (Topt=0 to 50°C)*Note	4.325 4.320	4.350 4.350	4.375 4.380	V V
V_{REL1}	Release voltage for over-charge detection		4.100	4.150	4.200	V
tV_{DET1}	Output delay of over-Charge	C=0.01µF, V_{DD}=3.6V to 4.4V	61	77	93	ms
tV_{REL1}	Output delay of Release from Over-charge	C=0.01µF, V_{DD}=4.4V to 4.1V	15	20	25	ms
V_{DET2}	Over-discharge threshold	Detect falling edge of supply Voltage	2.437	2.500	2.563	V
tV_{DET2}	Output delay of over-Discharge	V_{DD}=3.6V to 2.4V	12	17	22	ms
V_{DET3}	Excess current threshold	Detect rising edge of 'V-' pin Voltage	0.18	0.20	0.22	V
tV_{DET3}	Output delay of excess Current	V_{DD}=3.0V	7	10	13	ms
Vshort	Short protection voltage	V_{DD}=3.0V	V_{DD}-1.2	V_{DD}-0.9	V_{DD}-0.6	V
tshort	Output Delay of Short protection	V_{DD}=3.0V		5	50	µs
Rshort	Reset resistance for excess current protection	V_{DD}=3.6V, V- =1.0V	37	75	113	kΩ
Vol1	Nch ON voltage of C_{OUT}	Iol=40µA, V_{DD}=4.4V		0.3	0.5	V
Voh1	Pch ON voltage of C_{OUT}	Ioh=-40µA, V_{DD}=3.9V	3.4	3.7		V
Vol2	Nch ON voltage of D_{OUT}	Iol=40µA, V_{DD}=2.2V		0.2	0.5	V
Voh2	Pch ON voltage of D_{OUT}	Ioh=-40µA, V_{DD}=3.9V	3.4	3.7		V
I_{DD}	Supply current	V_{DD}=3.9V,V- =0V		6.0	10.0	µA
Istandby	Standby current	V_{DD}=2.0V			0.1	µA

*Note: 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 production tested.

■ TYPICAL APPLICATION



■ APPLICATION HINTS

R1 and C1 will stabilize a supply voltage to the R5422Nxxxx. A recommended R1 value is less than 1kΩ.
A larger value of R1 leads higher detection voltage, makes some errors, because of shoot through current flowed in the R5422Nxxxx.
R2 will stabilize a V- pin voltage. The resetting from over-discharge with connecting a charger possibly be disabled by larger value of R2. Recommended value is less than 1 kΩ.
R1 and R2 can operate also as a part of current limit circuit against for setting cell reverse direction or for applying excess charging voltage to the R5422Nxxxx, battery pack, while smaller R1 and R2 may cause a power consumption over rating of power dissipation of the R5422Nxxxx and a total of 'R1+R2' should be more than 1kΩ.