PRODUCT SPECIFICATIONS

R5400N110FA-TR-F

contents

[1] Outline

The R5400N110FA is high voltage tolerant CMOS-based protection IC for over-charge/discharge and over-current of rechargeable one-cell Lithium-ion (Li+)/Lithium polymer battery. The R5400N110FA 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 excess discharge-current. The R5400N110FA consists of three voltage detectors, a reference unit, a delay circuit, a short circuit detector, an oscillator, a counter, and a logic circuit.

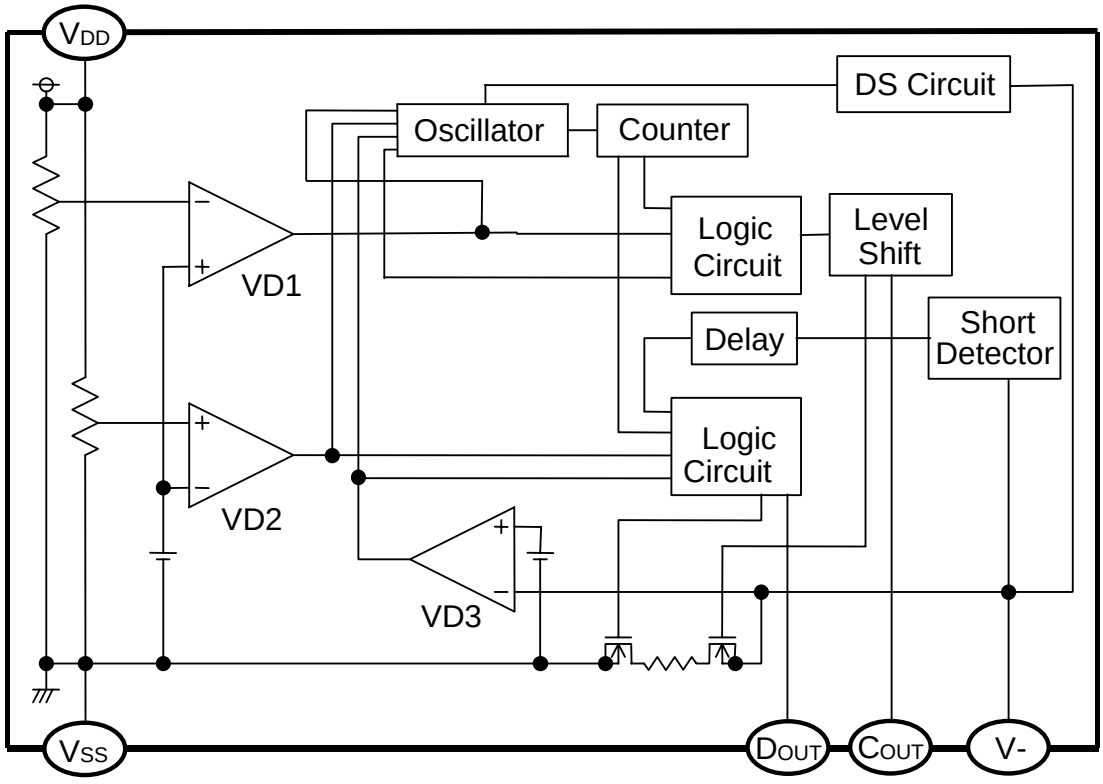
When the R5400N110FA detects over-charge, the output of COUT pin switches to "L" level, that is, the charger's negative pin level after the internal fixed delay time. When the R5400N110FA detects over-discharge or excess discharge current, the output of DOUT pin switches to "L" level after the internal fixed delay time.

After detecting over-charge voltage, if the battery voltage is lower than over-charge detector threshold, the R5400N110FA can be reset and the output of COUT becomes "H" when a kind of load is connected to VDD after a charger is disconnected from the battery pack. If a charger would be connected to the battery pack, even if the cell voltage becomes equal or lower than released voltage from over-charge, over-charge would not be 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 R5400N110FA is released and the voltage of DOUT pin becomes "H". Once after detecting excess discharge-current or short circuit, the R5400N110FA 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 the delay shortening mode voltage level (Typ. –2.0V), the output delay of most of all items except short circuit detector and excess discharge current detector can be shortened. Especially, the delay time of over charge detector can be reduced into approximately 1/60. Thus, testing time of protector circuit board can be reduced. Output type of COUT and DOUT is CMOS.

[2] Block Diagram



[3] Pin Description

Pin No.	Symbol	Pin description
1	V-	Charger negative Input Pin
2	V_{DD}	Power Supply Pin, the substrate level of the IC.
3	Vss	Ground Pin. The ground pin of the IC.
4	D_{OUT}	Output Pin of Over-discharge detection, CMOS output
5	C_{OUT}	Output Pin of Over-charge detection, CMOS output

[4] Absolute Maximum Rating

Topt=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}-35 to V_{DD}+0.3	 V
Output Voltage C_{OUT} pin Voltage D_{OUT} pin Voltage	 VC_{OUT} VD_{OUT}	 V_{DD}-35 to V_{DD}+0.3 Vss-0.3 to V_{DD}+0.3	 V V
Power Dissipation	P_D	150	mW
Operating Temperature	Topr	-40 to 85	°C
Storage Temperature	Tstg	-55 to 125	°C

[5] Electrical Characteristics

●R5400N110FA

Topt=25°C

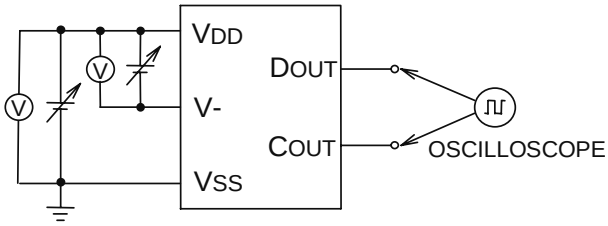
Item	Symbol	Conditions	Min.	Typ.	Max.	Unit	Note1
Operating Input Voltage	$V_{DD}1$	V_{DD} - Vss	1.5		5.0	V	A
Minimum Operating Voltage for 0V Charging	Vst	Voltage Defined as V_{DD}-V-, VDD-Vss=0V			1.8	V	A
Over-charge Threshold Voltage	$V_{DET}1$	R1=330Ω R1=330Ω, Topt=-5°C to 55°C *Note2	4.255 4.250	4.280 4.280	4.305 4.310	V V	B B
Output Delay of Over-charge	$tV_{DET}1$	V_{DD}=3.6V→4.4V	192	275	358	ms	B
Release Delay for VD1	$tV_{REL}1$	V_{DD}=4V, V-=0V→1V	12	17	22	ms	C
Over-discharge Threshold	$V_{DET}2$	Detect falling edge of supply voltage	2.242	2.300	2.358	V	D
Output Delay of Over-discharge	$tV_{DET}2$	V_{DD}=3.6V→2.0V	14	20	26	ms	D
Release Delay for VD2	$tV_{REL}2$	V_{DD}=3V, V-=3V→0V	0.7	1.2	1.7	ms	E
Excess discharge-current threshold	$V_{DET}3$	Detect rising edge of 'V-' pin voltage	0.110	0.125	0.140	V	F
Output delay of excess discharge-current	$tV_{DET}3$	V_{DD}=3.0V, V-=0V to 1V	8	12	16	ms	F
Output delay of release from excess discharge-current	$tV_{REL}3$	V_{DD}=3.0V, V-=3V to 0V	0.7	1.2	1.7	ms	F
Short Protection Voltage	Vshort	V_{DD}=3.0V	0.9	1.3	1.7	V	F
Delay Time for Short Protection	tshort	V_{DD}=3.0V, V-=0V to 3V	230	300	500	μs	F
Reset Resistance for Excess Current Protection	Rshort	V_{DD}=3.6V,V- =1.0V	30	60	90	kΩ	F
Delay Shortening Mode Voltage	V_{DS}	V_{DD}=4.4V	-1.4	-2.0	-2.6	V	G
Nch ON-Voltage of COUT	$V_{OL}1$	Iol=50μA, V_{DD}=4.5V		0.4	0.5	V	H
Pch ON-Voltage of COUT	$V_{OH}1$	Ioh=-50μA, V_{DD}=3.9V	3.4	3.7		V	I
Nch ON-Voltage of DOUT	$V_{OL}2$	Iol=50μA, V_{DD}=2.0V		0.2	0.5	V	J
Pch ON-Voltage of DOUT	$V_{OH}2$	Ioh=-50μA, V_{DD}=3.9V	3.4	3.7		V	K
Supply Current	I_{DD}	V_{DD}=3.9V, V- =0V		3.5	7.0	μA	L
Standby Current	$I_{standby}$	V_{DD}=2.0V			0.1	μA	L

●: 'Note1' indicates test circuits shown in next page.

Note2: 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.

[6] Test Circuits

A



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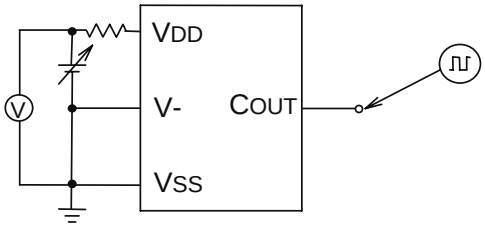

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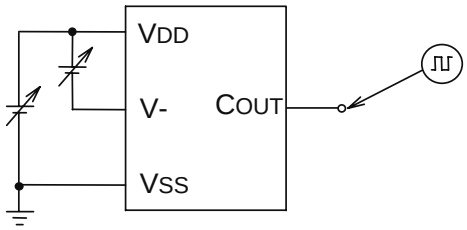

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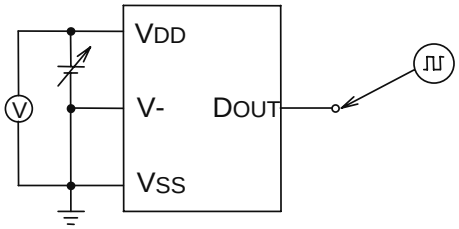

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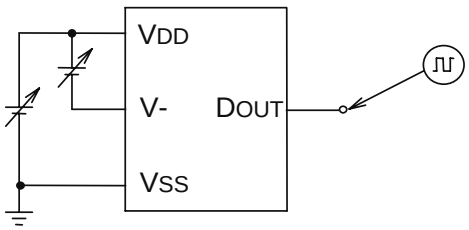

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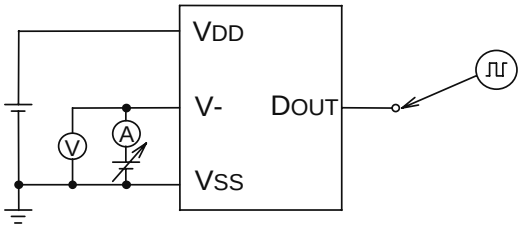

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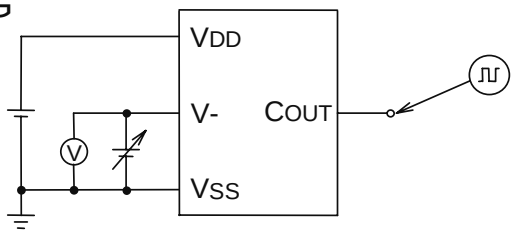
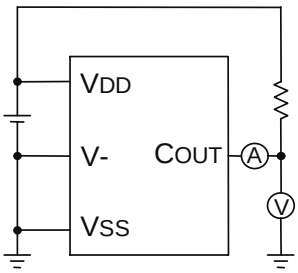


H



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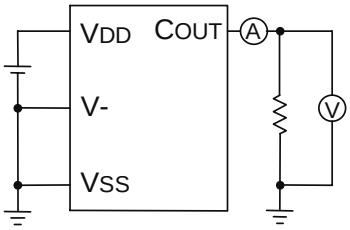

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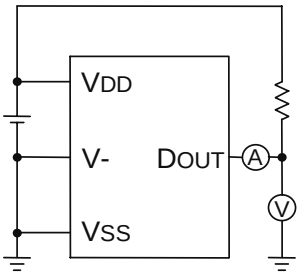

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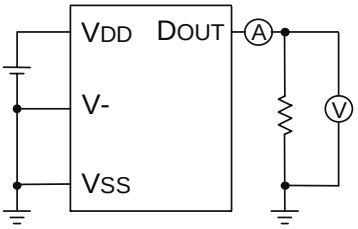
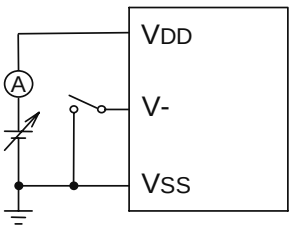


L



[7] Operation

• VD1 / Over-charge Detector

The VD1 monitors V_{DD} pin voltage during charge. When the V_{DD} voltage crosses over-charge detector threshold V_{DET1} (Typ. 4.28V), the VD1 can sense over-charge and the output of C_{OUT} pin becomes “L” and stop charging by turning off the external Nch-MOSFET.

After detecting over-charge, when the voltage of V_{DD} pin is less than over-charge detector threshold, if the charger is removed and a load is connected, VD1 is released, then the output level of C_{OUT} becomes “H” and by turning on the external Nch-MOSFET, the battery charger is ready to work again. In other words, once detecting over-charge, even if the battery voltage is down, while the charger is connected, recharge is not accepted. Thus, there is no hysteresis for over-charge detector. To judge whether or not a load is connected, over-discharge detector is used. Therefore, by connecting a load, when the V- pin voltage becomes equal or more than over-discharge current detector threshold, this IC realizes connecting a load, then released from over-charge.

When the Input level of V_{DD} pin is equal or more than over-charge detector threshold, and while a charger is disconnected from the battery pack, if a load system is connected to the battery pack, the output level of C_{OUT} pin is “L”. However, load current can be drawn through a parasitic diode of an external Nch-MOSFET. Then, when the voltage level of V_{DD} pin becomes lower than over-charge detector threshold, the output level of C_{OUT} pin becomes “H”.

Output delay time for over-charge detect and released over-charge is internally fixed respectively. Although the V_{DD} voltage goes up to a higher level than over-charge detector threshold within the output delay time (Typ. 275ms), VD1 would not work for detecting over-charge. If the action for VD1 to release is done and the condition returns to the initial one within the output delay time (Typ.17ms), VD1 cannot be released.

A level shifter is built in a buffer driver for the C_{OUT} pin, because of this, the “L” level is equal to the voltage level of V- pin.

The output type of C_{OUT} pin is CMOS type. (The Output level is between V_{DD} and V-.)

• VD2/Over-discharge Detector

The VD2 monitors a V_{DD} pin voltage during discharge. When the V_{DD} voltage crosses the over-discharge detector threshold V_{DET2} (Typ. 2.30V) from a high level to a lower level than V_{DET2}, the VD2 senses over-discharge and stop discharge by turning off an external Nch-MOSFET.

To reset the VD2 with the D_{OUT} pin level being “H” again after detecting over-discharge, connecting a charger to the battery pack is the only method. When a charger is connected to the battery pack, and V_{DD} level is equal or less than over-discharge detector threshold, charge current goes through a parasitic diode of an external Nch MOSFET. When the voltage of V_{DD} is higher than the over-discharge detector threshold level, the output level of D_{OUT} becomes “H” and by turning on an external Nch MOSFET, the battery pack can be discharged. When a charger is connected to the battery pack and V_{DD} level is higher than over-discharge voltage threshold, the output level of D_{OUT} becomes “H” immediately.

When a cell voltage is equal to 0V, connecting a charger to the battery pack makes C_{OUT} pin become "H" and the system is allowable for charge while the voltage of the charger is more than the maximum limit of the minimum operating voltage (Vst) for 0V charge.

An output delay for over-discharge detection is fixed internally. (Typ. 20ms) Although the voltage of V_{DD} becomes equal or less than over-discharge detector threshold and if it becomes higher than over-discharge detector threshold within output delay time, over-discharge detector does not work. Output delay time for release from over-discharge is also set internally. (Typ. 1.2ms)

After detecting over-discharge by VD2, supply current would decrease, (V_{DD}=2.0V, Max. 0.1μA.) because all circuits are halted and being standby.

The output type of D_{OUT} pin is CMOS type and its output level is in between V_{DD} and V_{SS}.

• VD3/ Excess Discharge Current Detector, Short Circuit Protector

While charge and discharge are acceptable with the battery pack, VD3 monitors the voltage level of V- pin. In the cause of such as the external short-circuit, if the voltage level of V- pin may become equal or more than the excess discharge current threshold voltage (Typ. 0.125V) and less than the short detector threshold (Typ. 1.3V), the excess discharge current detector works. When the voltage level of V- pin becomes equal or more than short detector threshold voltage, the short circuit protector works and the output level of D_{OUT} becomes “L”, and by turning off an external Nch MOSFET, VD3 protects against flowing extremely large current into the circuit.

An output delay time for the excess discharge current detector is internally fixed at 12ms typical. Although the voltage of V- pin becomes equal or more than the excess discharge current threshold voltage and less than short detector threshold, if it becomes less than the excess current detector threshold voltage within the output delay time, the excess current detector does not work. Output delay time for release from excess discharge current is also set internally (Typ. 1.2ms).

In terms of short circuit protector, output delay time is typically 300μs.

The V- pin has a built-in pull down resistor, Typ. 60kΩ connected to the Vss pin.

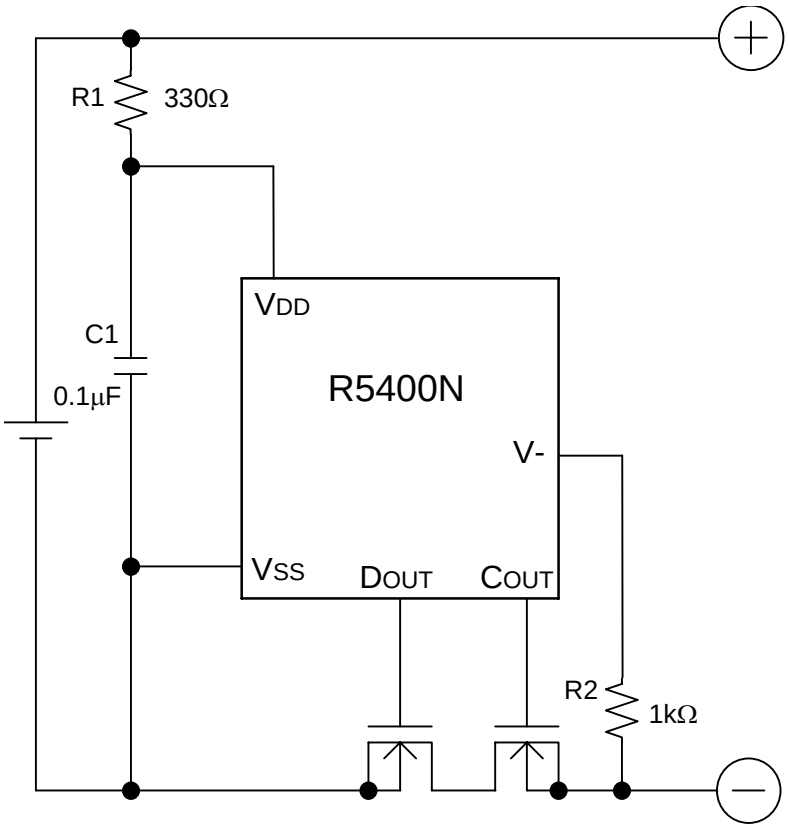
After an excess discharge current or short circuit protection is detected, by removing a cause of excess current or external short circuit, the voltage level of V- is pulled down through the resistor for release from excess current to the Vss level. Then, when the voltage level of V- pin becomes equal or less than the excess current threshold voltage, both protection circuits are released automatically. Resistor for release from excess discharge current is active when excess discharge current or short circuit is detected. While charge and discharge are acceptable for the battery pack, or normal mode, the resistor is inactive.

Output delay time for excess discharge current is necessarily set shorter than output delay time for over-discharge. Therefore, if excess discharge current is detected, and at the same time, V_{DD} pin voltage becomes lower than over-discharge detector threshold level, excess discharge current detector is predominant. By disconnecting load from the battery pack, the battery pack is automatically released from excess current state.

• DS (Delay Shortening) function

Output delay time of over-charge, over-discharge, and release from those detecting modes can be shortened than those setting values by forcing equal or less than delay shortening mode voltage (Typ. –2.0V) to V- pin.

[8] Technical Notes

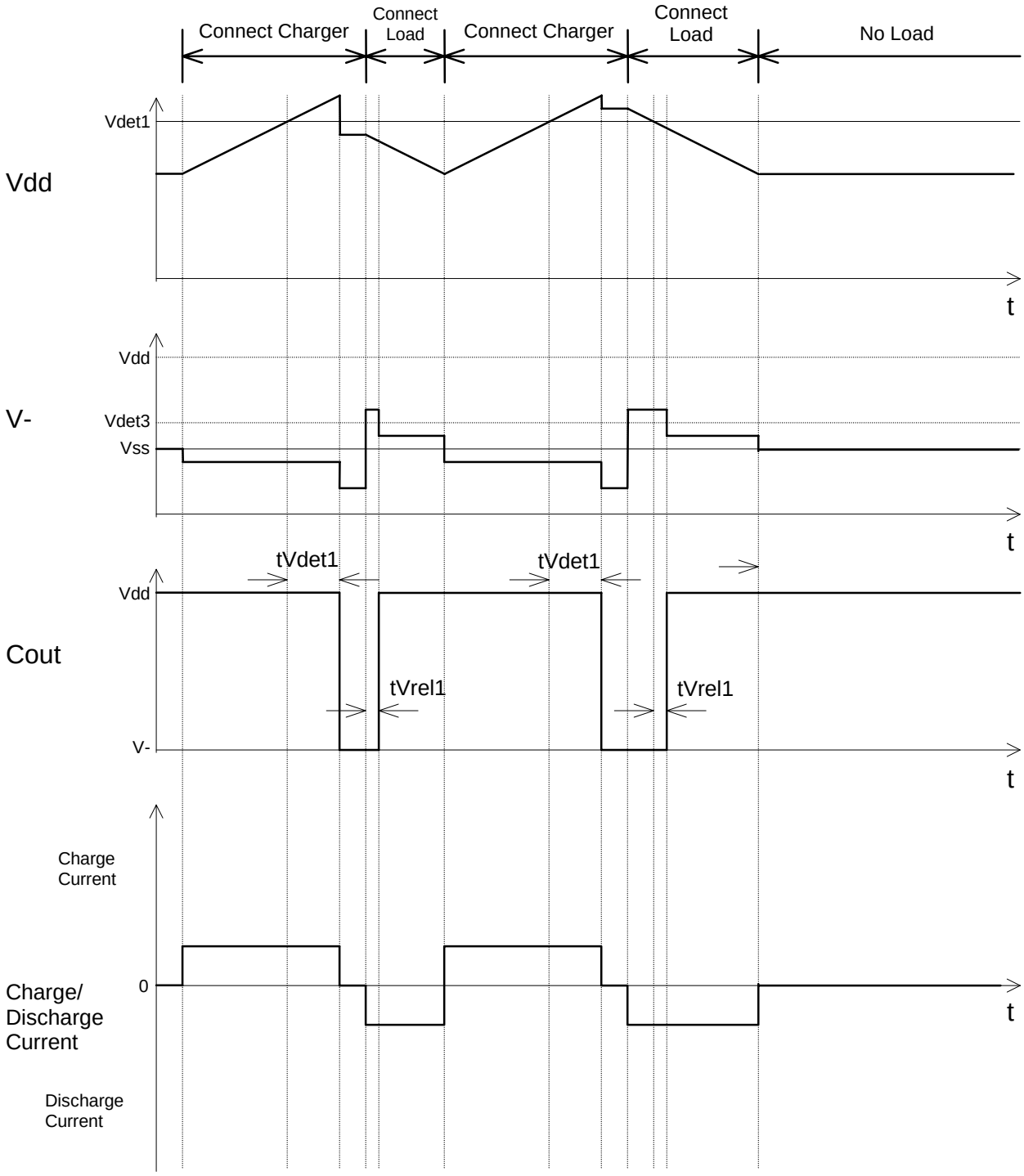


*R1 and C1 stabilize a supply voltage to the R5400. A recommended R1 value is less than 1kΩ. A large value of R1 makes detection voltage shift higher because of conduction current flown in the R5400.
Further, to stabilize the operation of R5400, use the C1 with the value of 0.01μF or more.

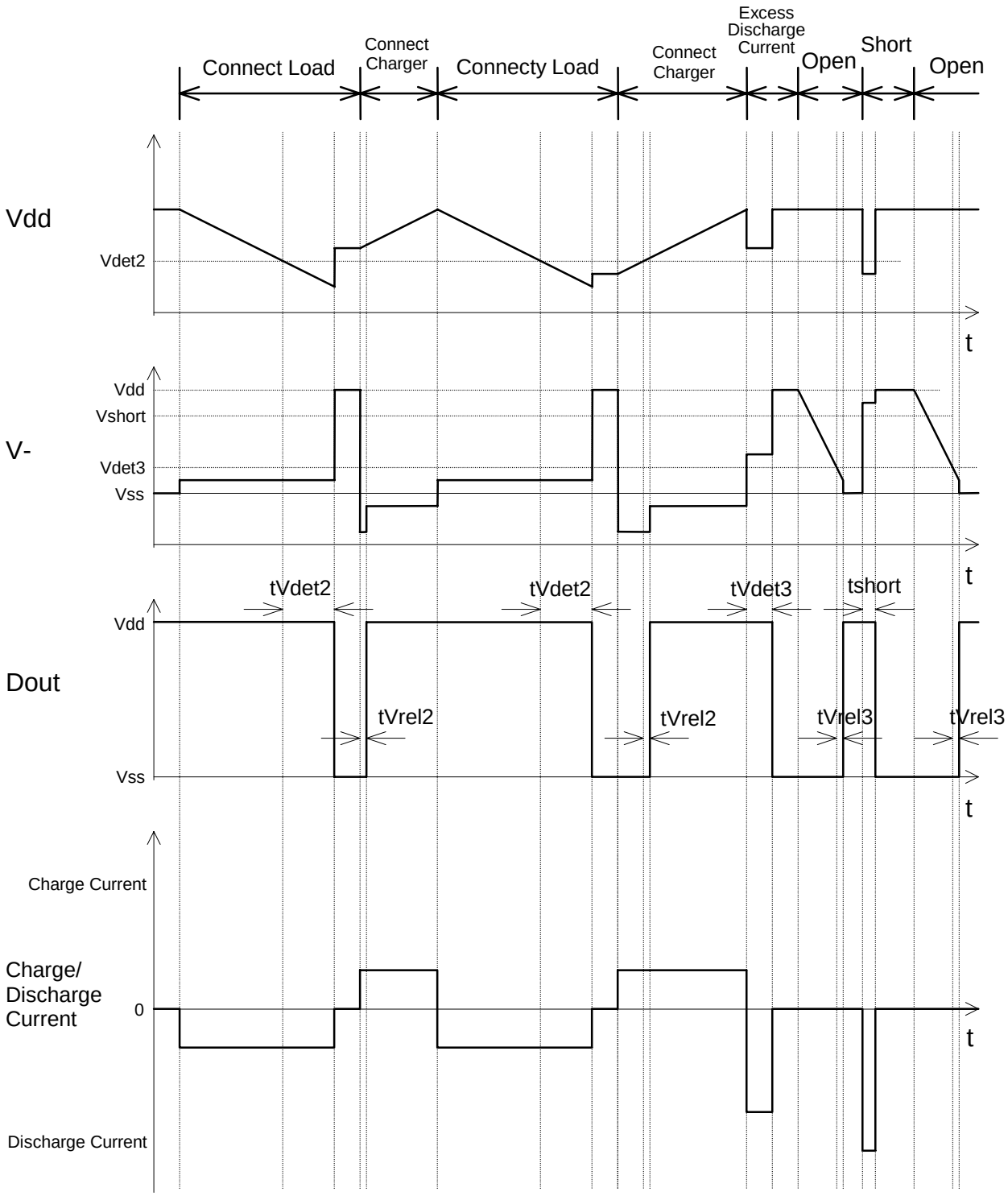
*R1 and R2 can operate as a current limit against setting cell reverse direction or applying excess charge voltage to the R5400. While small value of R1 and R2 may cause over power dissipation rating of the R5400, therefore a total of “R1+R2” should be 1kΩ or more. Besides, if large value of R2 is set, release from over-discharge by connecting a charger might not be possible. Recommended R2 value is equal or less than 10kΩ.

[9] Timing Diagram

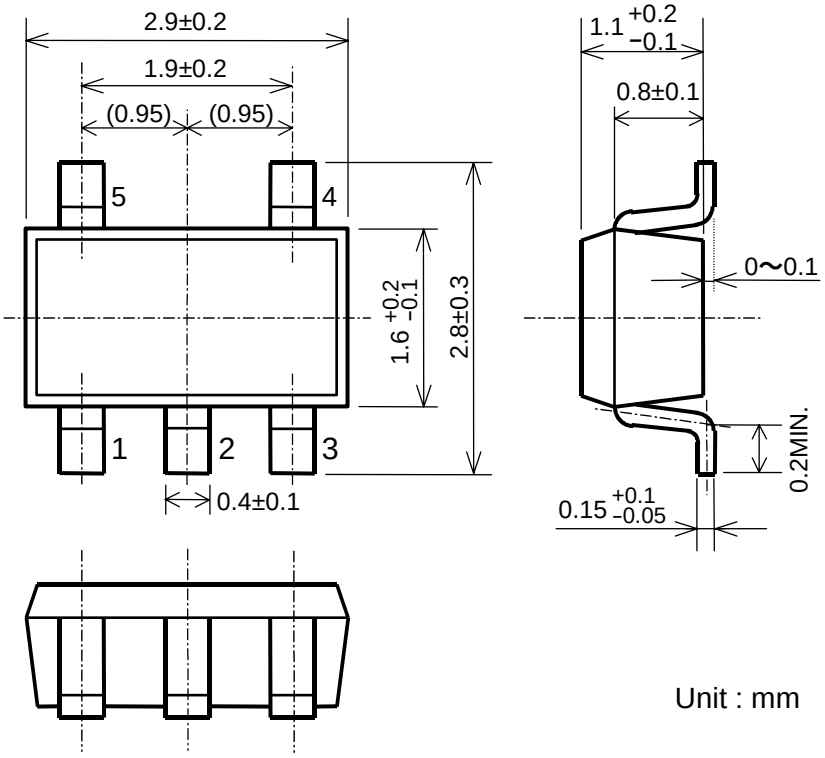
(1) Timing diagram of over-charge detector



(2) Over-discharge, Excess discharge current, Short circuit Operation



[10] Package Dimensions (SOT-23-5pin)



Unit : mm

[11] Mark Specification

①②③: Series Code Name … K10

④⑤: Lot Number (Alphanumeric serial number)