

## Li-Ion BATTERY PROTECTOR R5421NxxxC/xxxF series

### ■ OUTLINE

The R5421NxxxC/F 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 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 " $V_{RELI}$ ", 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 " $V_{RELI}$ " in the R5421NxxxC/F 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 R5421NxxxC/F 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. In the case of F version, after detecting the over-discharge detection, when the battery supply voltage becomes equal or higher than over-discharge released voltage, VD2 is also released by the condition, 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. The output delay of over-charge detectors can be set by connecting external capacitors. Output type of  $C_{OUT}$  and  $D_{OUT}$  are CMOS. 6-pin, SOT23-6 is available.

### ■ FEATURES

- Low supply current.....Supply current  
Standby current (detecting over-discharge)
 

Typ. 3.0 $\mu$ A
Typ. 0.3 $\mu$ A (for R5421NxxxC)
Typ. 1.0 $\mu$ A (for R5421NxxxF)
- High accuracy detector threshold .....Over-charge detector ( $T_{opt}=25^{\circ}C$ )  
( $T_{opt}=0$  to  $50^{\circ}C$ )
 

$\pm 25mV$
$\pm 30 mV$
$\pm 2.5\%$
- Variety of detector threshold .....Over-discharge detector
 

Over-charge detector threshold	4.0V - 4.4V step of 0.005V
Over-discharge detector threshold	2.0V - 3.0V step of 0.005V
- Built-in protection circuit .....Excess current protection
 

Accuracy	0.05V - 0.4V step of 0.005V
	$\pm 15\%$
- Output delay of over-charge .....Time delay at  $C_3=0.01\mu F$  and  $V_{DD}=4.3V$ 

75ms for R5421N111C
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- Output delay of over-discharge ..... $V_{DD}=2.4V$  with built-in capacitor
 

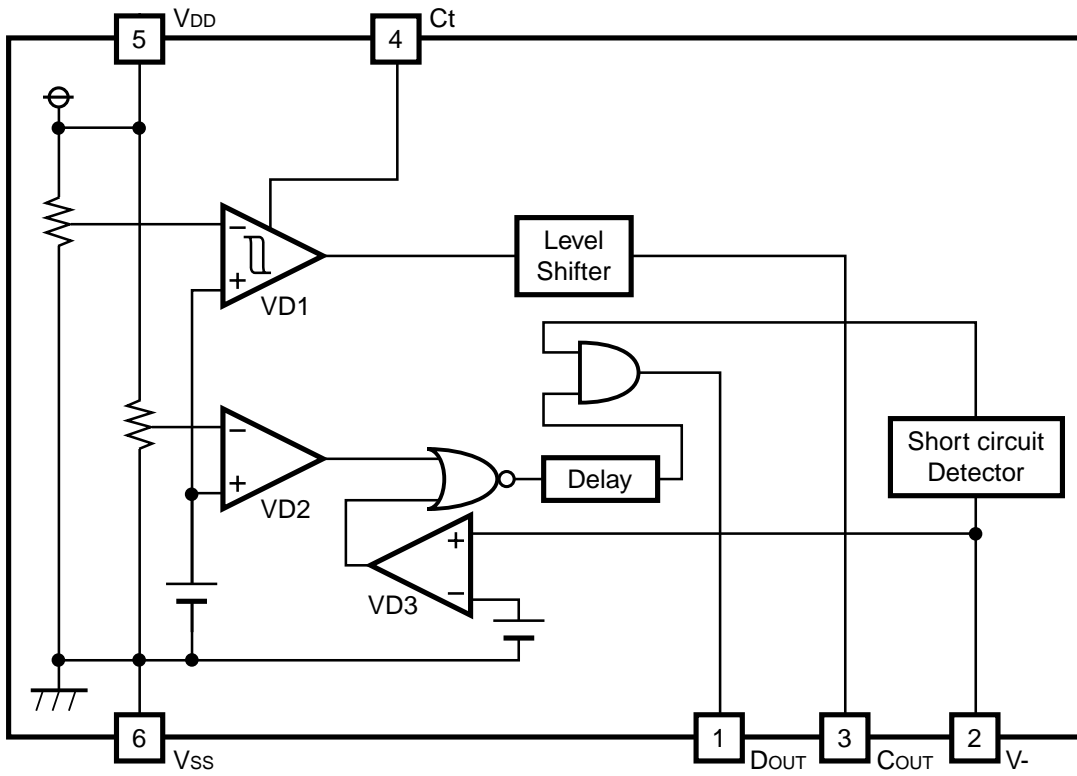
10ms for R5421N111C/112C
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- Small package.....SOT-23-6 / 6-pin

### ■ APPLICATIONS

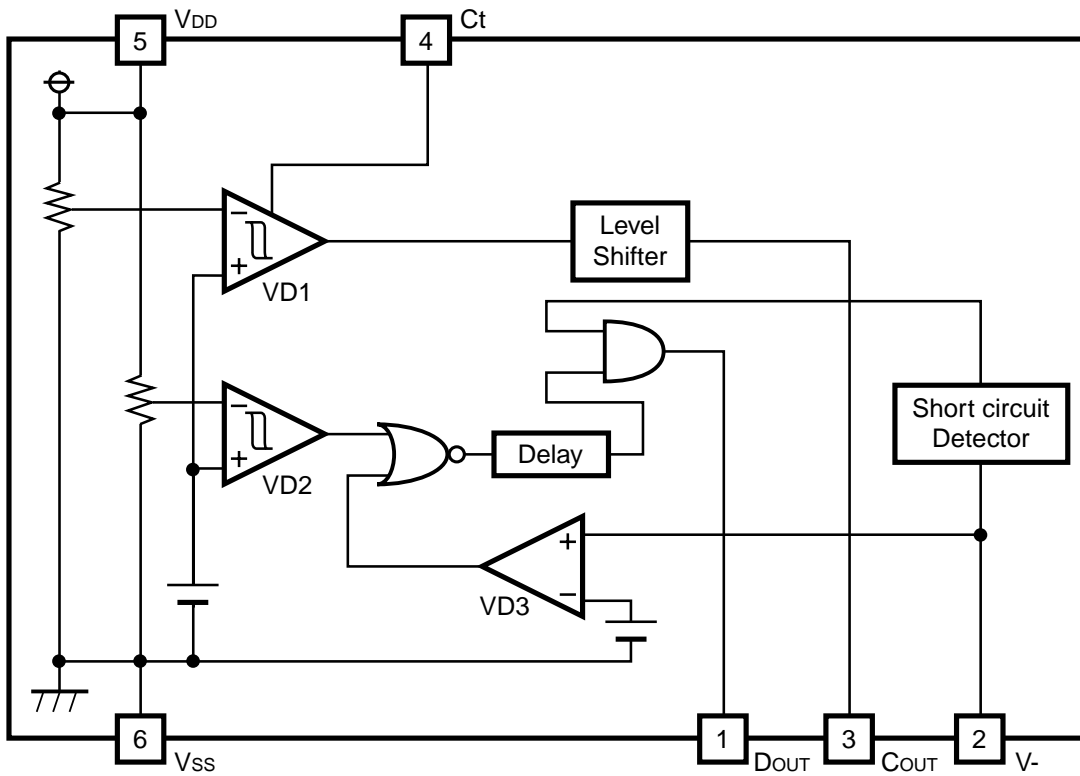
- Li+ one-cell protector for battery pack
- High precision protectors for cell-phones and any other gadgets using on board Li+ one-cell battery

■ **BLOCK DIAGRAM**

- R5421NxxxC



- R5421NxxxF



## SELECTION GUIDE

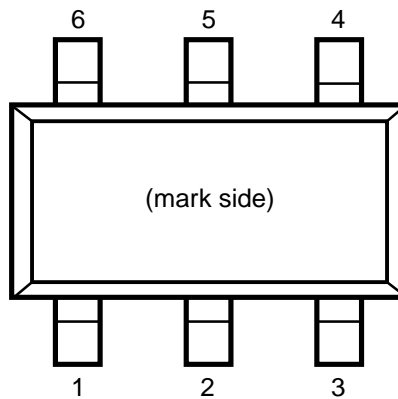
In the R5421Nxxxx Series three of the input threshold for over-charge, over-discharge and excess current detectors can be designated.

Part Number is designated as follows:

R5421N XXXX-XX ←Part Number  
           ↑  ↑  ↑  
           a  b  c

Code	Description
a	Serial Number for the R5421N 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 <sub>OUT</sub>	Output of over-discharge detection, CMOS output
2	V <sub>-</sub>	Pin for charger negative input
3	C <sub>OUT</sub>	Output of over-charge detection, CMOS output
4	C <sub>t</sub>	Pin for external capacitor setting output delay of VD1
5	V <sub>DD</sub>	Power supply
6	V <sub>SS</sub>	Ground

## ■ 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	$V_{DD} - 28$ to $V_{DD} + 0.3$	V
	Ct pin	$V_{SS} - 0.3$ to $V_{DD} + 0.3$	V
VCOUT VDOUT	Output voltage		
	COUT pin	$V_{DD} - 28$ to $V_{DD} + 0.3$	V
	DOUT pin	$V_{SS} - 0.3$ to $V_{DD} + 0.3$	V
$P_D$	Power dissipation	150	mW
$T_{opt}$	Operating temperature range	-40 to 85	°C
$T_{stg}$	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

### ● R5421N111C

Top=25°C

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V <sub>DD1</sub>	Operating input voltage	Voltage defined as V <sub>DD</sub> - V <sub>SS</sub>	1.5		10	V
V <sub>St</sub>	Minimum operating Voltage for 0V charging	Voltage defined as V <sub>DD</sub> - V <sub>-</sub> , V <sub>DD</sub> - V <sub>SS</sub> =0V			1.2	V
V <sub>DET1</sub>	Over-charge threshold	Detect rising edge of supply voltage (Top=25°C) (Top=0 to 50°C) <sup>*Note</sup>	4.225 4.220	4.250 4.250	4.275 4.280	V V
V <sub>REL1</sub>	Release voltage for over-charge detection		4.00	4.05	4.10	V
tV <sub>DET1</sub>	Output delay of over-Charge	C3=0.01μF, V <sub>DD</sub> =3.6V to 4.3V	60	75	90	ms
V <sub>DET2</sub>	Over-discharge threshold	Detect falling edge of supply voltage	2.437	2.500	2.563	V
tV <sub>DET2</sub>	Output delay of over-Discharge	V <sub>DD</sub> =3.6V to 2.4V	7	10	13	ms
V <sub>DET3</sub>	Excess current threshold	Detect rising edge of 'V-' pin voltage	0.17	0.20	0.23	V
tV <sub>DET3</sub>	Output delay of excess Current	V <sub>DD</sub> =3.0V	9	13	17	ms
V <sub>short</sub>	Short protection voltage	V <sub>DD</sub> =3.0V	V <sub>DD</sub> -1.2	V <sub>DD</sub> -0.9	V <sub>DD</sub> -0.6	V
t <sub>short</sub>	Output Delay of Short protection	V <sub>DD</sub> =3.0V		5	50	μs
R <sub>short</sub>	Reset resistance for Excess current protection	V <sub>DD</sub> =3.6V, V <sub>-</sub> =1.0V	50	100	150	kΩ
V <sub>ol1</sub>	Nch ON voltage of C <sub>OUT</sub>	I <sub>ol</sub> =50μA, V <sub>DD</sub> =4.4V		0.35	0.5	V
V <sub>oh1</sub>	Pch ON voltage of C <sub>OUT</sub>	I <sub>oh</sub> =-50μA, V <sub>DD</sub> =3.9V	3.4	3.7		V
V <sub>ol2</sub>	Nch ON voltage of D <sub>OUT</sub>	I <sub>ol</sub> =50μA, V <sub>DD</sub> =2.4V		0.2	0.5	V
V <sub>oh2</sub>	Pch ON voltage of D <sub>OUT</sub>	I <sub>oh</sub> =-50μA, V <sub>DD</sub> =3.9V	3.4	3.7		V
I <sub>DD</sub>	Supply current	V <sub>DD</sub> =3.9V, V <sub>-</sub> =0V		3.0	6.0	μA
I <sub>standby</sub>	Standby current	V <sub>DD</sub> =2.0V		0.3	0.6	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.

● R5421N112C

Topt=25°C

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V <sub>DD1</sub>	Operating input voltage	Voltage defined as V <sub>DD</sub> - V <sub>SS</sub>	1.5		10	V
V <sub>st</sub>	Minimum operating Voltage for 0V charging	Voltage defined as V <sub>DD</sub> - V <sub>-</sub> , V <sub>DD</sub> - V <sub>SS</sub> =0V			1.2	V
V <sub>DET1</sub>	Over-charge threshold	Detect rising edge of supply Voltage Topt=25°C Topt=0 to 50°C*Note	4.325 4.320	4.350 4.350	4.375 4.380	V V
V <sub>REL1</sub>	Release voltage for over-charge detection		4.100	4.150	4.200	V
tV <sub>DET1</sub>	Output delay of over-Charge	C3=0.01μF, V <sub>DD</sub> =3.6V to 4.4V	61	77	93	ms
V <sub>DET2</sub>	Over-discharge threshold	Detect falling edge of supply Voltage	2.437	2.500	2.563	V
tV <sub>DET2</sub>	Output delay of over-Discharge	V <sub>DD</sub> =3.6V to 2.4V	7	10	13	ms
V <sub>DET3</sub>	Excess current threshold	Detect rising edge of 'V-' pin Voltage	0.17	0.20	0.23	V
tV <sub>DET3</sub>	Output delay of excess Current	V <sub>DD</sub> =3.0V	9	13	17	ms
V <sub>short</sub>	Short protection voltage	V <sub>DD</sub> =3.0V	V <sub>DD</sub> -1.2	V <sub>DD</sub> -0.9	V <sub>DD</sub> -0.6	V
t <sub>short</sub>	Output Delay of Short protection	V <sub>DD</sub> =3.0V		5	50	μs
R <sub>short</sub>	Reset resistance for excess current protection	V <sub>DD</sub> =3.6V, V <sub>-</sub> =1.0V	50	100	150	kΩ
V <sub>ol1</sub>	Nch ON voltage of C <sub>OUT</sub>	I <sub>ol</sub> =50μA, V <sub>DD</sub> =4.4V		0.35	0.5	V
V <sub>oh1</sub>	Pch ON voltage of C <sub>OUT</sub>	I <sub>oh</sub> =-50μA, V <sub>DD</sub> =3.9V	3.4	3.7		V
V <sub>ol2</sub>	Nch ON voltage of D <sub>OUT</sub>	I <sub>ol</sub> =50μA, V <sub>DD</sub> =2.4V		0.2	0.5	V
V <sub>oh2</sub>	Pch ON voltage of D <sub>OUT</sub>	I <sub>oh</sub> =-50μA, V <sub>DD</sub> =3.9V	3.4	3.7		V
I <sub>DD</sub>	Supply current	V <sub>DD</sub> =3.9V, V <sub>-</sub> =0V		3.0	6.0	μA
I <sub>standby</sub>	Standby current	V <sub>DD</sub> =2.0V		0.3	0.6	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.

● R5421N151F

T<sub>opt</sub>=25°C

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V <sub>DD1</sub>	Operating input voltage	Voltage defined as V <sub>DD</sub> - V <sub>SS</sub>	1.5		10	V
V <sub>st</sub>	Minimum operating Voltage for 0V charging	Voltage defined as V <sub>DD</sub> - V <sub>-</sub> , V <sub>DD</sub> - V <sub>SS</sub> =0V			1.2	V
V <sub>DET1</sub>	Over-charge threshold	Detect rising edge of supply Voltage T <sub>opt</sub> =25°C T <sub>opt</sub> =0 to 50°C*Note	4.225 4.220	4.250 4.250	4.275 4.280	V V
V <sub>REL1</sub>	Release voltage for over-charge detection		4.000	4.050	4.100	V
tV <sub>DET1</sub>	Output delay of over-Charge	C3=0.01μF, V <sub>DD</sub> =3.6V to 4.3V	60	75	90	ms
V <sub>DET2</sub>	Over-discharge threshold	Detect falling edge of supply Voltage	2.437	2.500	2.563	V
tV <sub>DET2</sub>	Output delay of over-Discharge	V <sub>DD</sub> =3.6V to 2.4V	7	10	13	ms
V <sub>DET3</sub>	Excess current threshold	Detect rising edge of 'V-' pin Voltage	0.17	0.20	0.23	V
tV <sub>DET3</sub>	Output delay of excess Current	V <sub>DD</sub> =3.0V	9	13	17	ms
V <sub>short</sub>	Short protection voltage	V <sub>DD</sub> =3.0V	V <sub>DD</sub> -1.2	V <sub>DD</sub> -0.9	V <sub>DD</sub> -0.6	V
t <sub>short</sub>	Output Delay of Short protection	V <sub>DD</sub> =3.0V		5	50	μs
R <sub>short</sub>	Reset resistance for excess current protection	V <sub>DD</sub> =3.6V, V <sub>-</sub> =1.0V	50	100	150	kΩ
V <sub>ol1</sub>	Nch ON voltage of C <sub>OUT</sub>	I <sub>ol</sub> =50μA, V <sub>DD</sub> =4.4V		0.35	0.5	V
V <sub>oh1</sub>	Pch ON voltage of C <sub>OUT</sub>	I <sub>oh</sub> =-50μA, V <sub>DD</sub> =3.9V	3.4	3.7		V
V <sub>ol2</sub>	Nch ON voltage of D <sub>OUT</sub>	I <sub>ol</sub> =50μA, V <sub>DD</sub> =2.2V		0.2	0.5	V
V <sub>oh2</sub>	Pch ON voltage of D <sub>OUT</sub>	I <sub>oh</sub> =-50μA, V <sub>DD</sub> =3.9V	3.4	3.7		V
I <sub>DD</sub>	Supply current	V <sub>DD</sub> =3.9V, V <sub>-</sub> =0V		3.0	6.0	μA
I <sub>standby</sub>	Standby current	V <sub>DD</sub> =2.0V		1.0	2.0	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.

● R5421N152F

T<sub>opt</sub>=25°C

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V <sub>DD1</sub>	Operating input voltage	Voltage defined as V <sub>DD</sub> - V <sub>SS</sub>	1.5		10	V
V <sub>st</sub>	Minimum operating Voltage for 0V charging	Voltage defined as V <sub>DD</sub> - V <sub>-</sub> , V <sub>DD</sub> - V <sub>SS</sub> =0V			1.2	V
V <sub>DET1</sub>	Over-charge threshold	Detect rising edge of supply Voltage T <sub>opt</sub> =25°C T <sub>opt</sub> =0 to 50°C*Note	4.325 4.320	4.350 4.350	4.375 4.380	V V
V <sub>REL1</sub>	Release voltage for over-charge detection		4.100	4.150	4.200	V
tV <sub>DET1</sub>	Output delay of over-Charge	C3=0.01μF, V <sub>DD</sub> =3.6V to 4.4V	61	77	93	ms
V <sub>DET2</sub>	Over-discharge threshold	Detect falling edge of supply Voltage	2.437	2.500	2.563	V
tV <sub>DET2</sub>	Output delay of over-Discharge	V <sub>DD</sub> =3.6V to 2.4V	7	10	13	ms
V <sub>DET3</sub>	Excess current threshold	Detect rising edge of 'V-' pin Voltage	0.17	0.20	0.23	V
tV <sub>DET3</sub>	Output delay of excess Current	V <sub>DD</sub> =3.0V	9	13	17	ms
V <sub>short</sub>	Short protection voltage	V <sub>DD</sub> =3.0V	V <sub>DD</sub> -1.2	V <sub>DD</sub> -0.9	V <sub>DD</sub> -0.6	V
t <sub>short</sub>	Output Delay of Short protection	V <sub>DD</sub> =3.0V		5	50	μs
R <sub>short</sub>	Reset resistance for excess current protection	V <sub>DD</sub> =3.6V, V <sub>-</sub> =1.0V	50	100	150	kΩ
V <sub>ol1</sub>	Nch ON voltage of C <sub>OUT</sub>	I <sub>ol</sub> =50μA, V <sub>DD</sub> =4.4V		0.35	0.5	V
V <sub>oh1</sub>	Pch ON voltage of C <sub>OUT</sub>	I <sub>oh</sub> =-50μA, V <sub>DD</sub> =3.9V	3.4	3.7		V
V <sub>ol2</sub>	Nch ON voltage of D <sub>OUT</sub>	I <sub>ol</sub> =50μA, V <sub>DD</sub> =2.2V		0.2	0.5	V
V <sub>oh2</sub>	Pch ON voltage of D <sub>OUT</sub>	I <sub>oh</sub> =-50μA, V <sub>DD</sub> =3.9V	3.4	3.7		V
I <sub>DD</sub>	Supply current	V <sub>DD</sub> =3.9V, V <sub>-</sub> =0V		3.0	6.0	μA
I <sub>standby</sub>	Standby current	V <sub>DD</sub> =2.0V		1.0	2.0	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.



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## ■ OPERATION

### ● VD1 / Over-Charge Detector in the 'C' version

The VD1 monitors  $V_{DD}$  pin voltage. When the  $V_{DD}$  voltage crosses over-charge detector threshold  $V_{DET1}$  from a low value to a value higher than the  $V_{DET1}$ , the VD1 can sense a over-charging and an external charge control Nch-MOS-FET turns to “OFF” with  $C_{OUT}$  pin being at “Low” level.

There can be two cases to reset the VD1 making the  $C_{OUT}$  pin level to “High” again after detecting over-charge. Resetting the VD1 can make charging system allowable to resumption of charging process.

The first case is in such conditions that a time when the  $V_{DD}$  voltage is coming down to a level lower than “ $V_{RELI}$ ”.

While in the second case, connecting a kind of loading to  $V_{DD}$  after disconnecting a charger from the battery pack can make the VD1 resetting when the  $V_{DD}$  level is in between “ $V_{DET1}$ ” and “ $V_{RELI}$ ”.

After detecting over-charge with the  $V_{DD}$  voltage of higher than  $V_{DET1}$ , connecting system load to the battery pack makes load current allowable through parasitic diode of external charge control FET.

The  $C_{OUT}$  level would be High when the  $V_{DD}$  level is coming down to a level below the  $V_{DET1}$  by continuous drawing of load current.

An output delay time for over-charge detection can be set by external capacitor C3 connecting between the  $V_{SS}$  pin and Ct pin. The external capacitor can make a delay time from a moment detecting over-charge to a time output a signal which enables charge control FET turn to “OFF”.

When the  $V_{DD}$  level is going up to a higher level than  $V_{DET1}$  if the  $V_{DD}$  voltage would be back to a level lower than the  $V_{DET1}$  within a time period of the output delay time, VD1 would not output a signal for turning “OFF” of charge control FET.

The output delay time can be calculated as below:

$$t_{VD1}[sec] = (C3[F] \times (V_{DD}[V]-0.7) / (0.48 \times 10^{-6}))$$

Note:  $T_{opt}=25^{\circ}C$   $V_{DD}$  value should be after over-charge detection.

A level shifter incorporated in a buffer driver for the  $C_{OUT}$  pin makes the “Low” level of  $C_{OUT}$  pin to the V - pin voltage and the “High” level of  $C_{OUT}$  pin is set to  $V_{DD}$  voltage with CMOS buffer.

### ● VD2 / Over-Discharge Detector

The VD2 is monitoring a  $V_{DD}$  pin voltage. When the  $V_{DD}$  voltage crosses the over-discharge detector threshold  $V_{DET2}$  from a high value to a value lower than the  $V_{DET2}$ , the VD2 can sense an over-discharging and the external discharge control Nch MOS FET turns to “OFF” with the  $D_{OUT}$  pin being at “Low” level.

To reset the VD2 with the  $D_{OUT}$  pin level being “H” again after detecting over-discharge it is necessary to connect a charger to the battery pack for R5421NxxxC. When the  $V_{DD}$  voltage stays under over- discharge detector threshold  $V_{DET2}$  charge current can flow through parasitic diode of external discharge control MOS FET, then after the  $V_{DD}$  voltage comes up to a value larger than  $V_{DET2}$ ,  $D_{OUT}$  becomes "H" and discharging process would be able to advance through ON state MOS FET for discharge control.

Connecting a charger to the battery pack makes the  $D_{OUT}$  level being “H” instantaneously when the  $V_{DD}$  voltage is higher than  $V_{DET2}$ .

Besides, for R5421NxxxF, when a cell voltage reaches equal or more than over-discharge released voltage, or  $V_{REL2}$ , over-discharge condition can be also released

When a cell voltage equals to zero, connecting charger to the battery pack makes the system allowable to charge with higher charge voltage than  $V_{st}$ , 1.2V Max.

An output delay time for the over-discharge detection is fixed internally,  $t_{VD2}=10ms$  typ. at  $V_{DD}=2.4V$ . When the  $V_{DD}$  level is going down to a lower level than  $V_{DET2}$  if the  $V_{DD}$  voltage would be back to a level higher than the  $V_{DET2}$  within a time period of the output delay time, VD2 would not output a signal for turning “OFF” of discharge control FET.

After detection of an over-discharge by VD2, supply current would be reduced to typically  $0.3\mu A$ (for R5421NxxxC) or  $1.0\mu A$ (for R5421NxxxF) at  $V_{DD}=2.0V$  and into standby, only the charger detector is operating.

The output type of  $D_{OUT}$  pin is CMOS having “H” level of  $V_{DD}$  and “L” level of  $V_{SS}$ .

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- VD3/Excess Current Detector, Short Circuit Protector

Both of the excess current detector and short circuit protector can work when both control FETs are in “ON” state. When the V- pin voltage is going up to a value between the short protection voltage  $V_{short}/V_{DD}$  and excess current threshold  $V_{DET3}$ , the excess current detector operates and further soaring of V- pin voltage higher than  $V_{short}$  makes the short circuit protector enabled. This leads the external discharge control Nch MOS FET turns to “OFF” with the D<sub>OUT</sub> pin being at “Low” level.

An output delay time for the excess current detector is internally fixed, 13ms typ. at  $V_{DD}=3.0V$ .

A quick recovery of V- pin level from a value between  $V_{short}$  and  $V_{DET3}$  within the delay time keeps the discharge control FET staying “High” state.

When the short circuit protector is enabled ,the D<sub>OUT</sub> would be Low and its delay time would be 5 $\mu$ s typ.

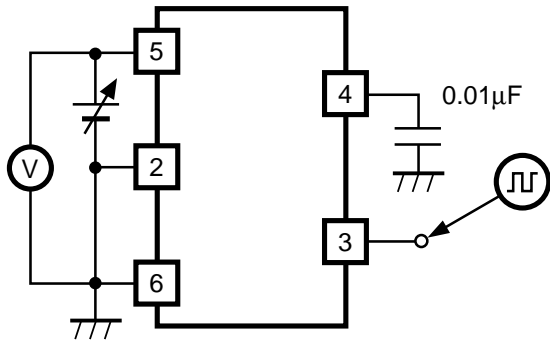
The V - pin has a built-in pulled down resistor ,typ.100k $\Omega$ , with connecting to the V<sub>SS</sub> pin.

After an excess current or short circuit protection is detected, removing a cause of excess current or external short circuit makes an external discharge control FET to an “ON” state automatically with the V- pin level being down to the V<sub>SS</sub> level through pulled down resistor built-in internally.

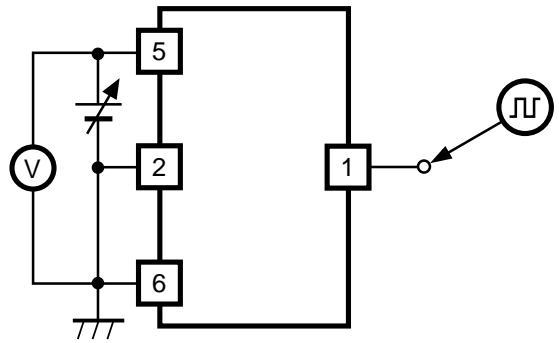
If  $V_{DD}$  voltage would be higher than  $V_{DET2}$  at a time when the excess current is detected the R5421N<sub>xxx</sub>C does not enter a standby mode, or otherwise in case of lower  $V_{DD}$  voltage than  $V_{DET2}$  would lead the R5421N<sub>xxx</sub>C into a standby.

After detecting short circuit the R5421N<sub>xxx</sub>C will not enter a standby mode.

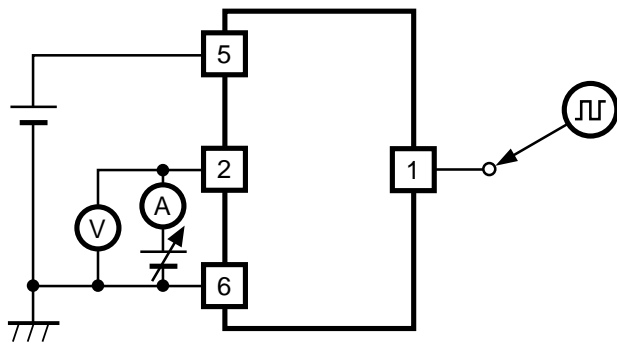
■ TEST CIRCUITS



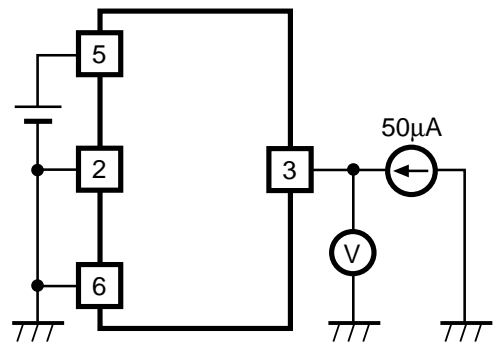
Test Circuit 1



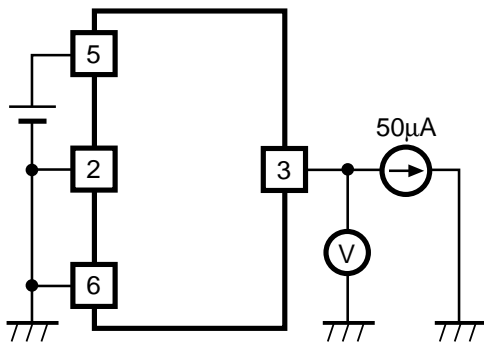
Test Circuit 2



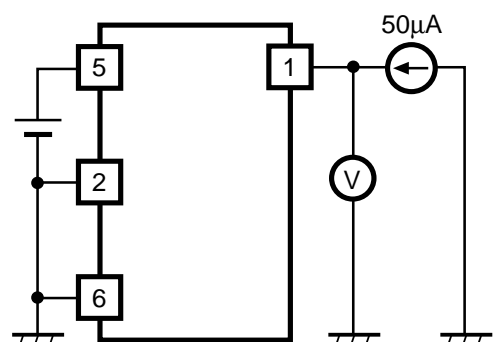
Test Circuit 3



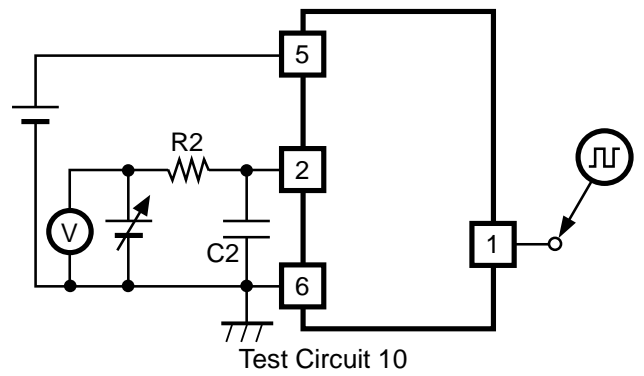
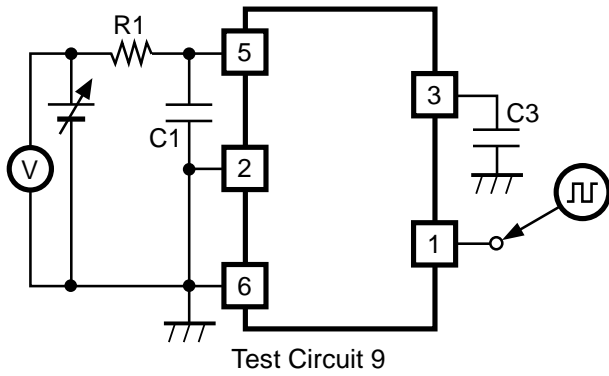
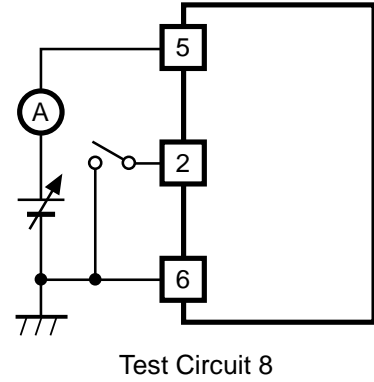
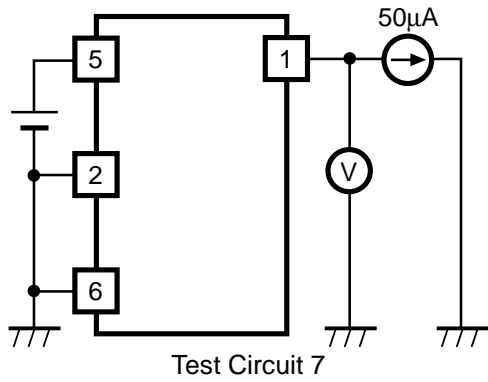
Test Circuit 4



Test Circuit 5



Test Circuit 6

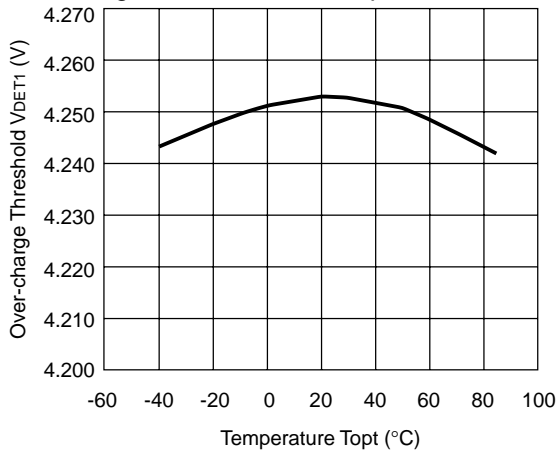


The typical characteristics were obtained by use of these test circuits.

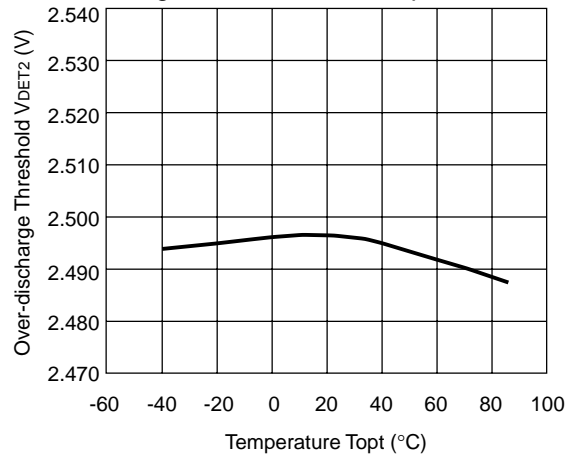
- Test Circuit 1 : Typical Characteristics 1) 5) 7) 17)
- Test Circuit 2 : Typical Characteristics 2) 6) 8)
- Test Circuit 3 : Typical Characteristics 3) 4) 9) 10) 19)
- Test Circuit 4 : Typical Characteristics 13)
- Test Circuit 5 : Typical Characteristics 14)
- Test Circuit 6 : Typical Characteristics 15)
- Test Circuit 7 : Typical Characteristics 16)
- Test Circuit 8 : Typical Characteristics 11) 12)
- Test Circuit 9 : Typical Characteristics 21)
- Test Circuit 10 : Typical Characteristics 18) 20)

## TYPICAL CHARACTERISTICS

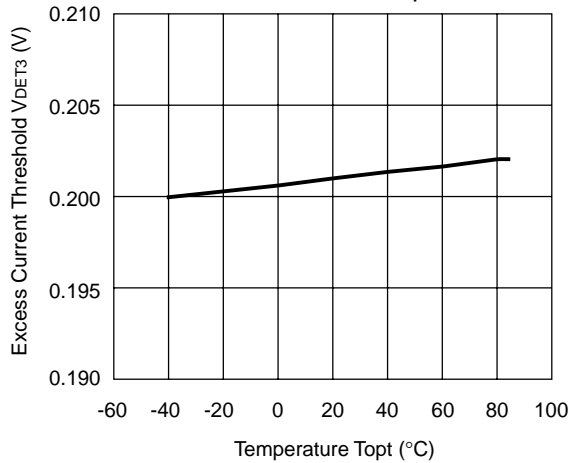
1) Over-charge Threshold vs. Temperature



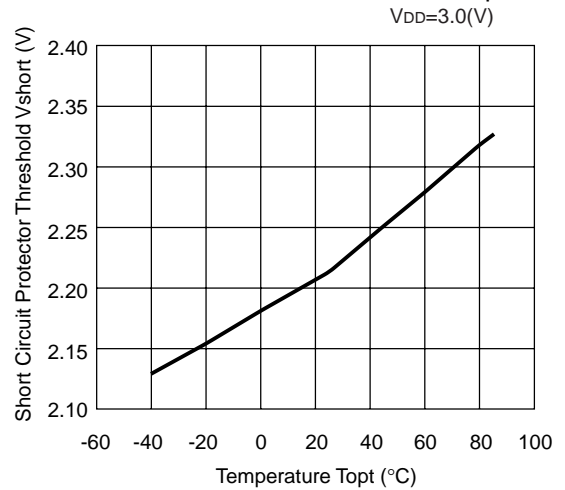
2) Over-discharge Threshold vs. Temperature



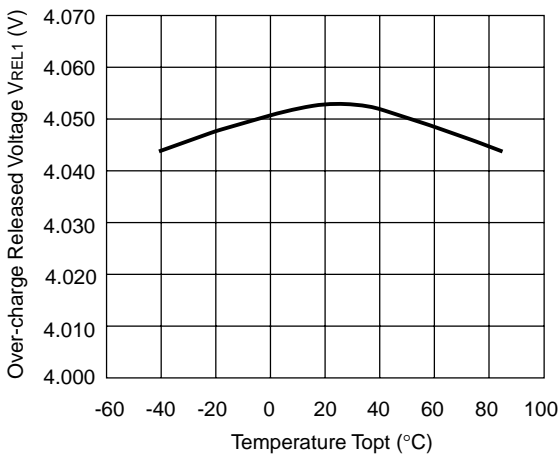
3) Excess Current Threshold vs. Temperature



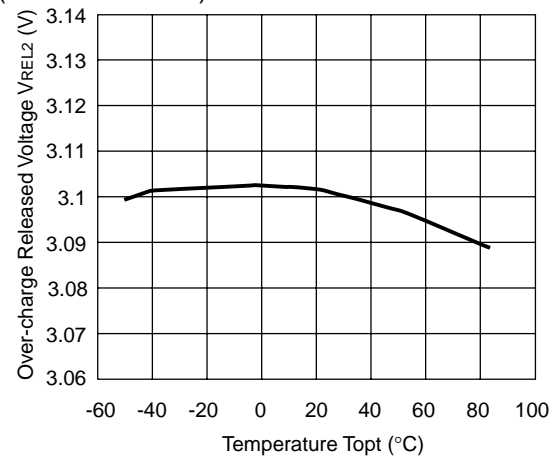
4) Short Circuit Protector Threshold vs. Temperature



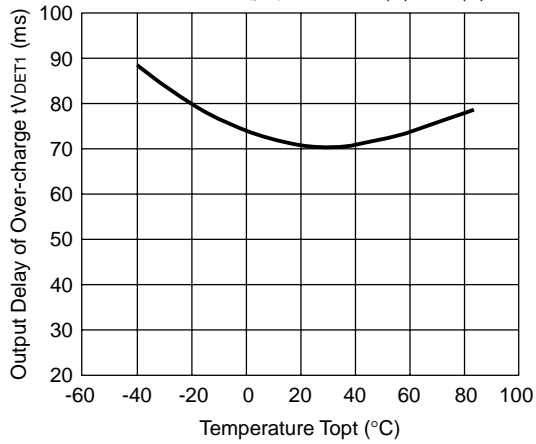
5) Over-charge Released Voltage vs. Temperature



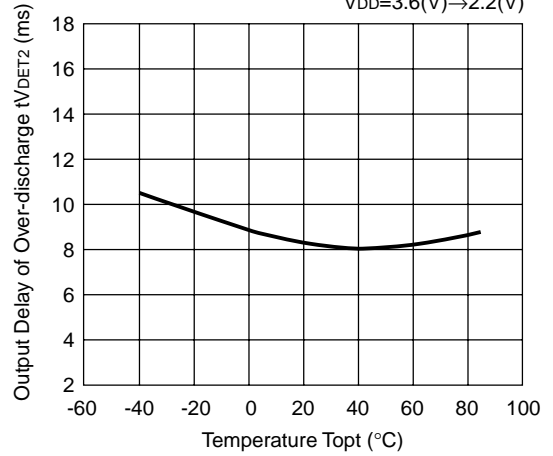
6) Over-discharge Released Voltage vs. Temperature (for R5421NxxxF)



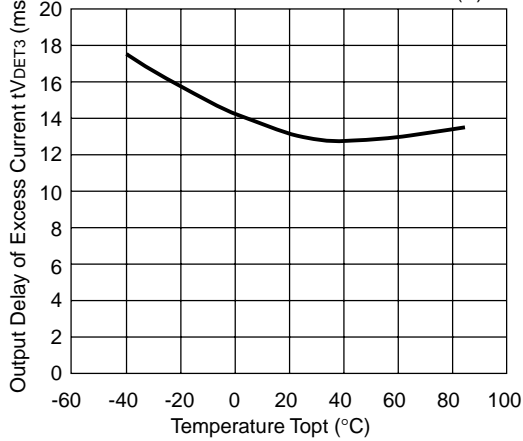
7) Output Delay of Over-charge vs. Temperature  
 $C=0.01(\mu\text{F})$   $V_{\text{DD}}=3.6(\text{V}) \rightarrow 4.3(\text{V})$



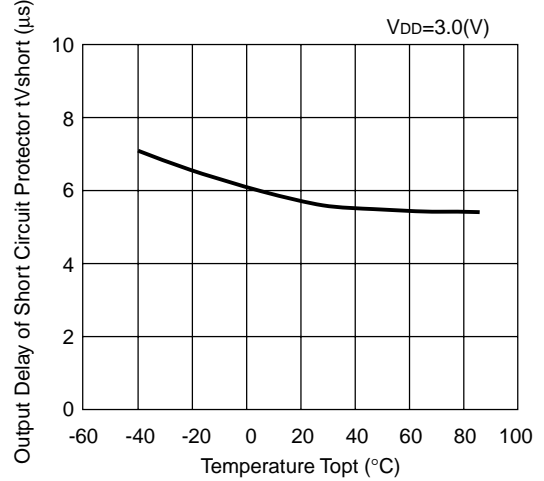
8) Output Delay of Over-discharge vs. Temperature  
 $V_{\text{DD}}=3.6(\text{V}) \rightarrow 2.2(\text{V})$



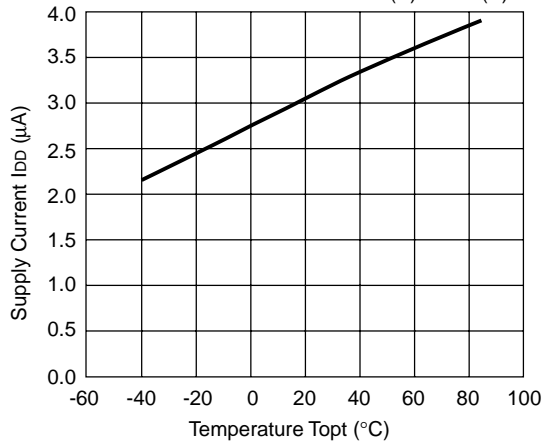
9) Output delay of Excess current vs. Temperature  
 $V_{\text{DD}}=3.0(\text{V})$



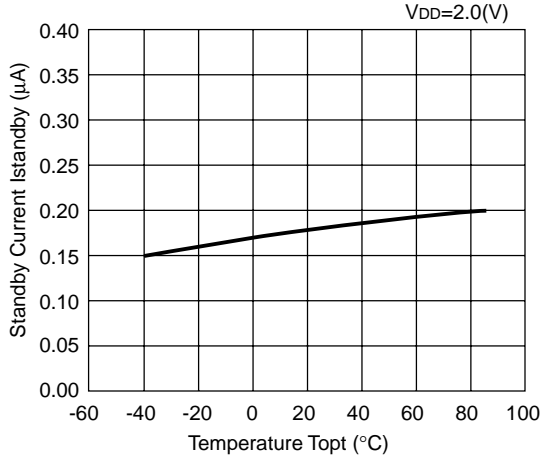
10) Output Delay of Short circuit protector vs. Temperature  
 $V_{\text{DD}}=3.0(\text{V})$



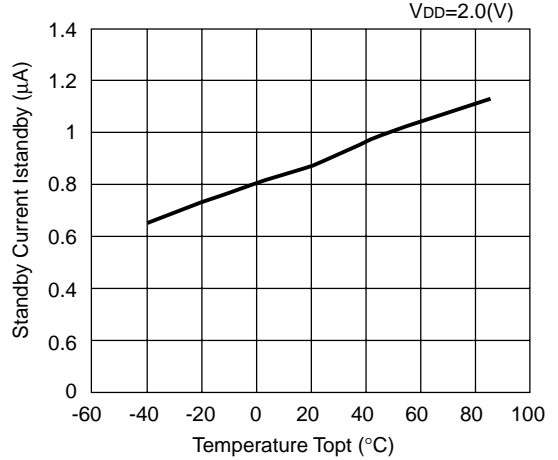
11) Supply Current vs. Temperature  
 $V_{\text{DD}}=3.9(\text{V})$   $V=0(\text{V})$



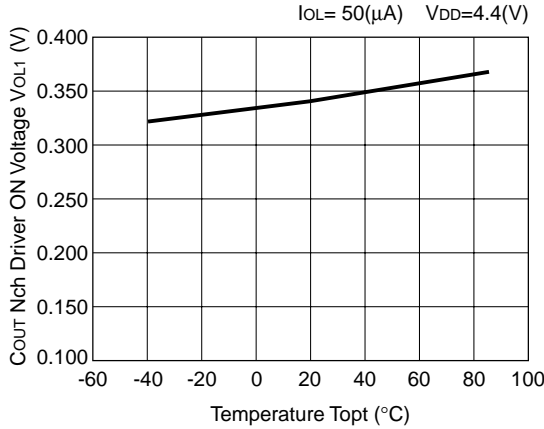
12) Supply Current vs. Temperature(for R5421NxxxC)



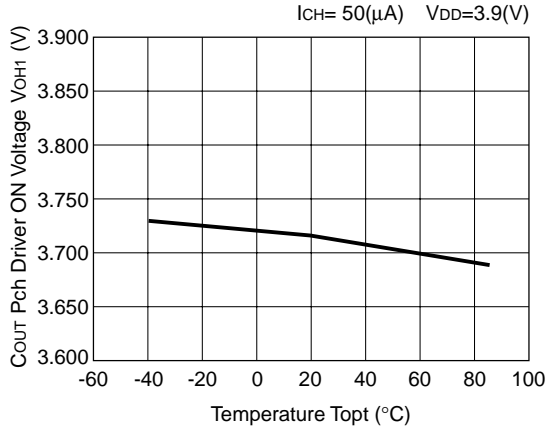
12) Standby Current vs. Temperature(for R5421NxxxF)



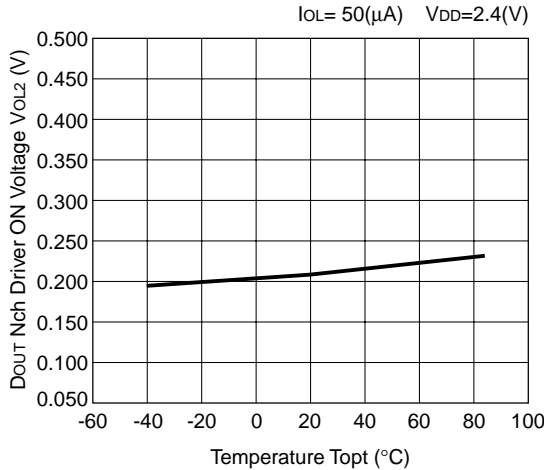
13) CO<sub>UT</sub> Nch Driver ON Voltage vs. Temperature



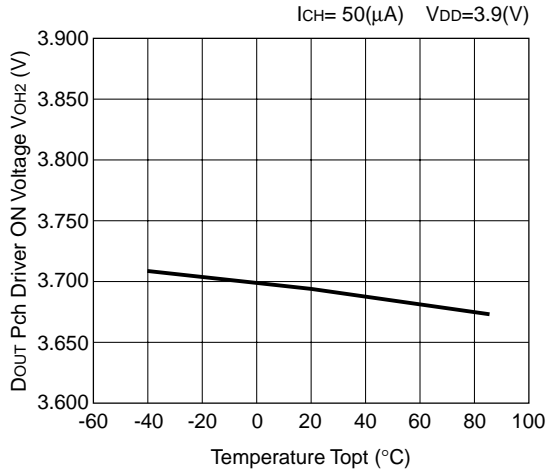
14) CO<sub>UT</sub> Pch Driver ON Voltage vs. Temperature



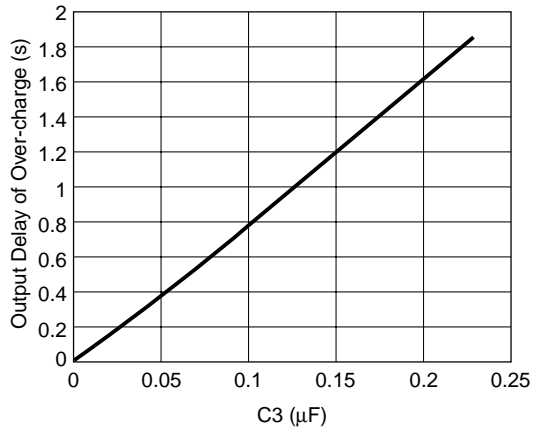
15) DO<sub>UT</sub> Nch Driver ON Voltage vs. Temperature



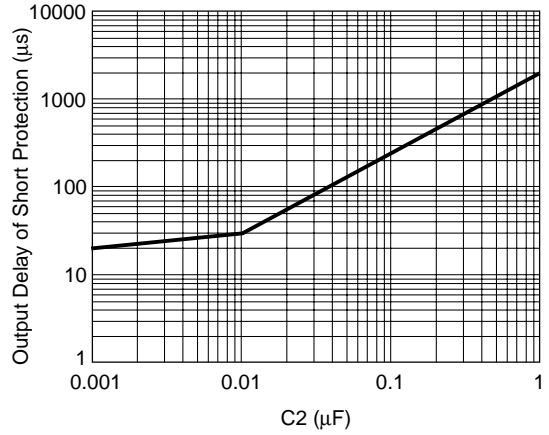
16) DO<sub>UT</sub> Pch Driver ON Voltage vs. Temperature



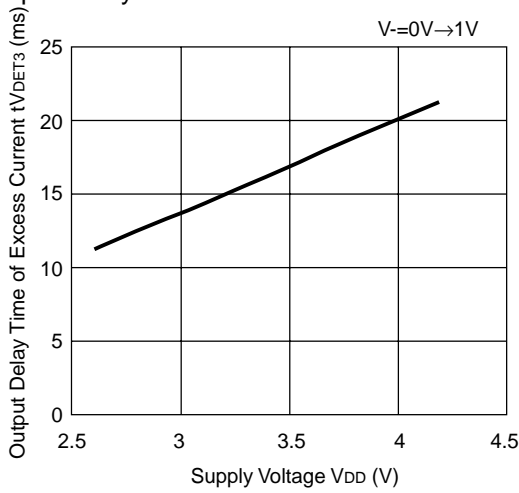
17) Output Delay of Over-charge vs. Capacitance C3  
 $V_{DD}=3.8V \rightarrow 4.3V$  ( $R1=100\Omega$ ,  $C1=0.1\mu F$ ,  $R2=1k\Omega$ ,  $C2=0.1\mu F$ )



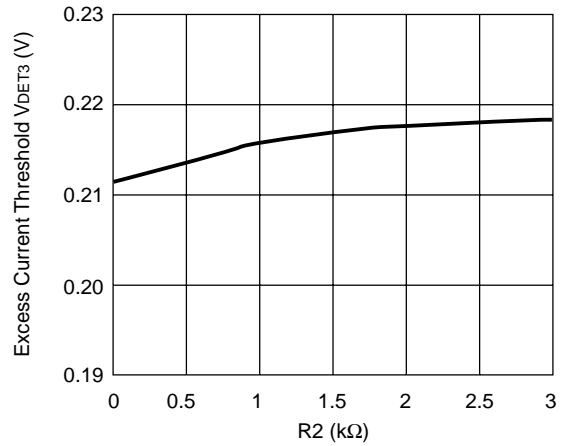
18) Output Delay of Short protection vs. Capacitance C2  
 $R1=100\Omega$ ,  $C1=0.1\mu F$ ,  $C3=0.01\mu F$ ,  $R2=1k\Omega$



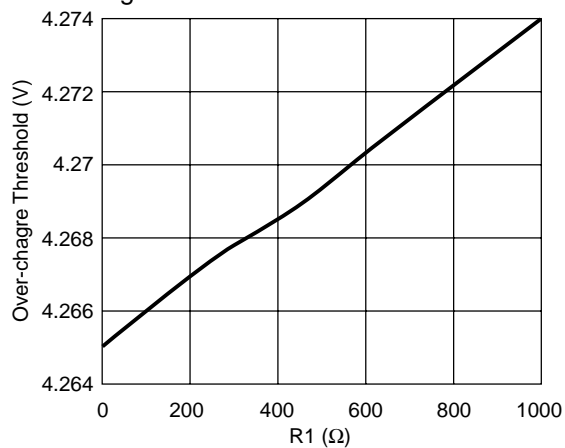
19) Output Delay of Excess Current vs.  $V_{DD}$   
 $V=0V \rightarrow 1V$



20) Excess Current Threshold vs. External Resistance R2

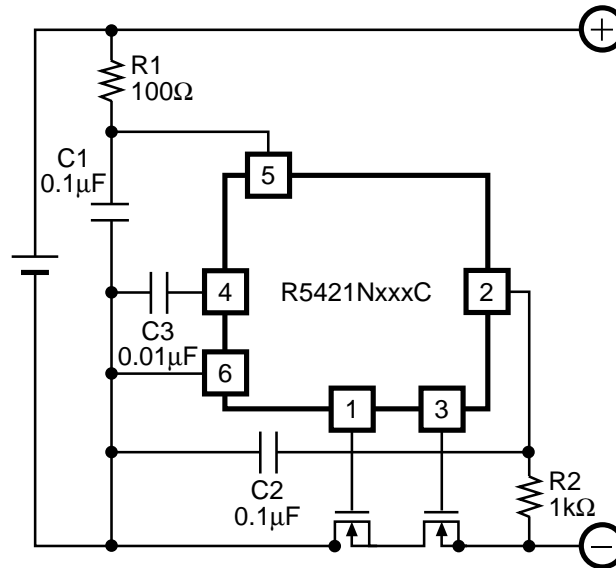


21) Over-charge Threshold vs. External Resistance R1





## ■ TYPICAL APPLICATION



## ■ APPLICATION HINTS

R1 and C1 will stabilize a supply voltage to the R5421NxxxC. 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 R5421NxxxC.

R2 and C2 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.

After an over-charge detection even connecting battery pack to a system probably could not allow a system to draw load current by a larger R2C2 time constant in the C version.

Recommended C2 value is less than 1μF.

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 R5421NxxxC, battery pack, while smaller

R1 and R2 may cause a power consumption over rating of power dissipation of the R5421NxxxC and a total of 'R1+R2' should be more than 1kΩ.

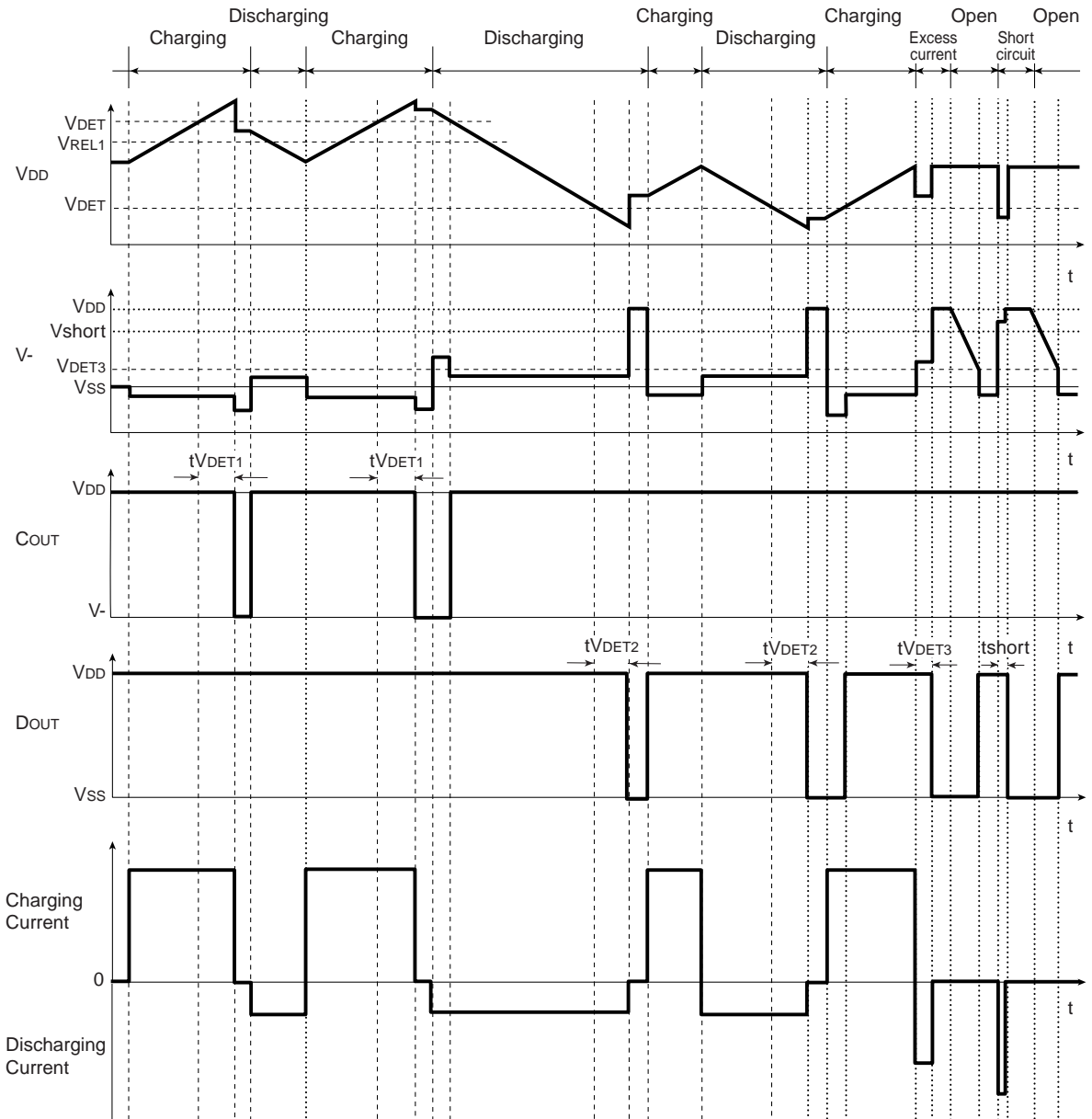
The time constants R1C1 or R2C2 must have a relations as below:

$$R1C1 \leq R2C2$$

Because in case that R1C1, time constant for V<sub>DD</sub> pin, would be larger than R2C2, time constant for V- pin, then the R5421NxxxC might be into a standby mode after detecting excess current or short circuit current.

## TIMING DIAGRAM

R5421NXXXC



● R5421NXXXF

