

# R5460x2xx SERIES

### Li-ION/POLYMER 2-CELL PROTECTOR

NO.EA-165-160603

### **OUTLINE**

The R5460x2xxxx Series are high voltage CMOS-based protection ICs for over-charge/discharge of rechargeable two-cell Lithium-ion (Li+) / Lithium polymer, further include a short circuit protection circuit for preventing large external short circuit current and the protection circuits against the excess discharge-current and excess charge current.

Each of these ICs is composed of six voltage detectors, a reference unit, a delay circuit, a short circuit protector, an oscillator, a counter, and a logic circuit. When the over-charge voltage threshold or excess-charge current threshold crosses the each detector threshold from a low value to a high value, the output of Cout pin switches to "L" level after internal fixed delay time. To release over-charge detector after detecting over-charge, the detector 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 and the cell voltage becomes lower than over-charge detector threshold. In case that a charger is continuously connected to the battery pack, if the cell voltage becomes lower than the over-charge released voltage, over-charge state is also released.

The output of Dout pin, the output of the over-discharge detector and the excess discharge-current detector, switches to "L" level after internally fixed delay time, when discharged voltage crosses the detector threshold from a high value to a value lower than VDET2.

The conditions to release over-discharge voltage detector after detecting over-discharge voltage are as follows:

A/D versions: after connecting a charger, when the cell voltage becomes higher than over-discharge detector threshold or, without connecting charger, when the cell voltage becomes equal or higher than over-discharge released voltage.

C version: after connecting a charger, when the cell voltage becomes higher than over-discharge detector threshold voltage.

E version: whether connecting a charger, or not, when the cell voltage becomes higher than released voltage from overdischarge.

F version: after connecting a charger, when the cell voltage becomes higher than released voltage from over-discharge.

In case that connecting a charger, for A/C/D versions, there is no hysteresis for over-discharge detector. E/F versions, even if a charger is connected to the battery pack, the hysteresis of over-discharge detector exists.

To satisfy the release conditions for over-discharge voltage protector, the output voltage of Dout becomes "H".

Even if a battery is discharged to 0V, charge current is acceptable.

After detecting excess-discharge current or short current, when the load is disconnected, the excess discharged or short condition is released and Dout becomes "H".

After detecting over-discharge voltage, supply current will be kept extremely low by halting internal circuits' operation.

When the output of Cout is "H", if V- pin level is set at -1.6V, the delay time of over-charge and over-discharge detector can be shortened. Especially, the delay time of the over-charge detector can be reduced into approximately 1/60 and test time for protection circuit PCB can be reduced. The output type of Cout and Dout is CMOS.

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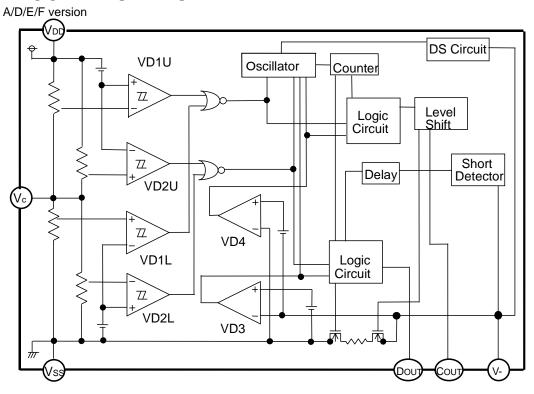
# **FEATURES**

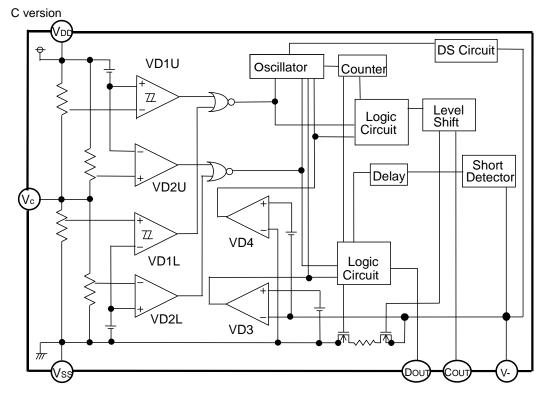
• N	Manufactured with High Voltage Tol	erant Process	Absolute Maximum Ratin	ıg	30V
• L	ow supply current		Supply current (At norma	ıl mode)	Тур. 4.0μΑ
			Standby current	Typ. 1.2µA (A	/ D/ E version)
				Max. 0.1μA (	C/ F version)
• +	High accuracy detector thres	shold	Over-charge detector	(Ta=25°C)	±25mV
				(Ta=-5 to 55°C)	±30mV
			Over-discharge detector		±2.5%
			Excess discharge-curren	t detector	±15mV
			Excess charge-current de	etector	±40mV
• \	/ariety of detector threshold				
		Over-charge detector the	hreshold (A/C/E/F version)	4.1V-4.5V step of 0.0	005V (VD1U/VD1L)
		Over-charge detector the	hreshold (D version)	3.5V-4.0V step of 0.0	005V (VD1U/VD1L)
		Over-discharge detector	or threshold	2.0V-3.0V step of 0.0	005V (Vd2u/Vd2l)
		Excess discharge-current	threshold	0.05V-0.20V step of	0.005V
		3 options of Excess	charge-current threshold	(1) -0.4V ±40mV	
				(2) -0.2V ±30mV	
				(3) -0.1V ±30mV	
		Over-charge release	ed voltage	0.1V-0.4V step of	0.05V (Vh1u/Vh1L)
		Over-discharge relea	ased voltage	0.2V-0.7V step of	0.1V (VH2U/VH2L)
• lı	nternal fixed Output delay ti	me	Over-charge detector Ou	tput Delay	1.0s
			Over-discharge detector	Output Delay	128ms
			Excess discharge-curren	t detector Output Delay	12ms
			Excess charge-current de	etector Output Delay	8ms
			Short Circuit detector Ou	tput Delay	300µs
Output Delay Time Shortening Function		At Cou⊤ is "H", if V- level is set at −1.6V, the Output Delay time			
			the over-charge and over	er-discharge can be redu	iced. (Delay Time for
			over-charge becomes ab	out 1/60 of normal state.	)
• 0	V-battery charge		acceptable		
• (	Jltra Small package		SOT-23-6, DFN(PLP)182	20-6	

# **APPLICATIONS**

- Li+ / Li Polymer protector of over-charge, over-discharge, excess-current for battery pack
- High precision protectors for cell-phones and any other gadgets using on board Li+ / Li Polymer battery

# **BLOCK DIAGRAMS**





NO.EA-165-160603

# **SELECTION GUIDE**

In the R5460x2xxxx Series, input threshold of over-charge, over-discharge, excess discharge current, and the package and taping can be designated.

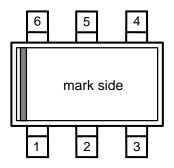
Part Number is designated as follows:

R5460x
$$\underline{2xxxx-xx}$$
 ←Part Number  $\uparrow \uparrow \uparrow \uparrow \uparrow$  a b c d e

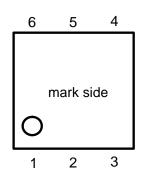
Code	Contents
а	Package Type N: SOT-23-6 K: DFN(PLP)1820-6
b	Serial Number for the R5460 Series designating input threshold for over-charge, over-discharge, excess discharge-current detectors.
С	Designation of Output delay option of over-charge and excess discharge-current.
d	Designation of version symbols.
е	Taping Type: TR (refer to Taping Specification)

# **PIN CONFIGURATIONS**





### DFN(PLP)1820-6



# **PIN DESCRIPTION**

Pin No.						
SOT-23-6	PLP1820-6	Symbol	Description			
1	3	<b>D</b> оит	Output pin of over-discharge detection, CMOS output			
2	1	Соит	Output pin of over-charge detection, CMOS output			
3	2	V-	Charger negative Input Pin			
4	6	VC	Input Pin of the center voltage between two-cell			
5	5	Vdd	Power supply pin, the substrate voltage level of the IC.			
6 4 Vss		Vss	Vss pin. Ground pin for the IC			

The backside tab of DFN(PLP)1820-6 package is connected to the substrate level. (VDD) Note that avoiding short with other level.

# **ABSOLUTE MAXIMUM RATINGS**

Ta=25°C, Vss=0V

Item	Symbol	Ratings	Unit
Supply Voltage	Vdd	-0.3 to 12	V
Input Voltage			
Middle pin Voltage between 2-cell	Vc	Vss-0.3 to V <sub>DD</sub> +0.3	V
V- pin Voltage	V-	V <sub>DD</sub> -30 to V <sub>DD</sub> +0.3	V
Output Voltage			
Соит pin Voltage	Vсоит	V <sub>DD</sub> -30 to V <sub>DD</sub> +0.3	V
D <sub>оит</sub> pin Voltage	VDOUT	Vss-0.3 to V <sub>DD</sub> +0.3	V
Power Dissipation	P <sub>D</sub>	150	mW
Operating Temperature	Та	-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.

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# **ELECTRICAL CHARACTERISTICS**

R5460x2xxAA/AD/AE version

Unless otherwise specified, Ta=25°C

Votation   Votation		therwise specified, Ta=25°C	Conditions	Min	T. //n	May	l ln:+
VSt. harging         Minimum operating Voltage for OV charge defined as VIDD-V-charging         Voltage defined as VIDD-V-charging         Last 1 (Voc-Vos-Seg-V)         Last 1 (Vos-Vos-Dage Vos-Vos-Vos-Vos-Vos-Vos-Vos-Vos-Vos-Vos-	Symbol	Operating input voltage	Conditions Voltage defined as Von-Ves	Min.	Тур.	Max.	Unit
Voetrom   Voe	V DD1			1.5		10.0	V
Vertical   Vertical	Vst		V <sub>DD</sub> -Vss=0V			1.8	V
Name							
VRELIU   CELL1 Over-charge released voltage   R1=33ΩΩ   VRELIU-0.05   VRELIU   VRELIU+0.05   V	VDET1U	CELL1 Over-charge threshold			VDET1U		V
Vicert   Output delay of release from over-charge   Voc-Ves-3.2V   Vo-Ves-3.2V   Vo			R1=330Ω (Ta=-5 to 55°C)*Note	VDET1U-0.030	VDET1U	VDET1U+0.030	V
Vocation   Vocation	V <sub>REL1U</sub>	CELL1 Over-charge released voltage	R1=330Ω	VREL1U-0.05	VREL1U	VREL1U+0.05	٧
t/RetL1         Output delay of release from over-charge         Voc=4.5V to 2.2V, Vc-Vss=3.2V         11         16         21         ms           Voc=11t.         CELL2 Over-charge detector threshold         R2=330Ω         Vcerti-0.025         Vcerti-0.025         Vcerti-0.025         Vcerti-0.025         Vcerti-0.025         Vcerti-0.025         Vcerti-0.003         Vcerti-0.025         Vcerti-0.003         Vcerti-0.003         Vcerti-0.025         Vcetti-0.025         Vcetti-0.025         Vcetti-0	tVDET1	Output delay of over-charge	1	0.7	1.0	1.3	s
Vertil   CELL2 Over-charge detector threshold   R2=330Ω   R2=330Ω   Vertil-0.025   Vertil-0.030   Vertil-0.0	tV <sub>REL1</sub>	Output delay of release from over-charge		11	16	21	ms
VbET1.1. VRELL1.         CELL2 Over-charge detector threshold         R2=330Ω (Ta=5 to 55°C) Nove (Pazil-0.030 Voeth 1.0030 Voeth 1.00300 Voeth 1.00300 Voeth 1.0030 Voeth 1.00300 Voeth 1.0030 Voeth 1.0030 Voeth 1.0030 Voeth		, ,					
Neb	V <sub>DET11</sub>	CFLL2 Over-charge detector threshold		VDET11-0.025	V <sub>DFT1I</sub>	VDET11+0.025	V
VRELLU   CELL1 Over-charge released voltage   R2=33ΩΩ   Detect falling edge of supply voltage   VoETZUV.0,975   VOETZUV.0,975   VOETZUV.1,025   V VOETZUV.0,975   VOETZUV.1,025   V VOETZUV.0,975   VOETZUV.1,025   V VOETZUV.1,0	· DETTE	o==== o ror oriango aorootor amooriora					-
Voetzu	\/	CELL 2 Over charge released veltage					
VRELZU discharge         CELL1 Released Voltage from Over-discharge         Detect rising edge of supply voltage         VRELZU VRELZU VRELZUX1.025         V           tVDETZ         CELL1 Released Voltage from Over-discharge         Vop-Vc=3.2V to 1.9V Vc- Vs=3.2V Vc- 0.7         1.2         1.7         ms           tVRELZU Dover-discharge         Vop-Vc=1.9V to 3.2V, Vc- Vs=3.2V Vc- Vs=3	V REL1L	CELLZ Over-charge released voltage	I.	V REL1L-0.03	V REL1L	V REL1L+0.03	V
VREEZU Jischarge         Detect Insing edge of Supply Voltage         VREEZUXX.9.75         VREEZUX.1.025         V           tVDeT2         Output delay of over-discharge         VDD-VC=3.2V to 1.9V to 3.2V, Vc- Vs=3.2V         0.7         1.2         1.7         ms           tVREL2         Output delay of release from over-discharge threshold         Detect falling edge of supply voltage         VDETZLX.0.975         VDETZLX.1.025         V           VRELZL SCELL2 Over-discharge threshold         Detect falling edge of supply voltage         VDETZLX.0.975         VDETZLX.1.025         V           VRELZL SCELL2 Released Voltage from Over-discharge         Detect fishing edge of supply voltage         VDETZLX.0.975         VRELZLX.0.975         VRELZLX.1.025         V           VDET3         Excess discharge-current threshold         Detect rising edge of vV- pin voltage         VDET3-0.015         VDET3-1         VDET		· ·		VDET2U×0.975	VDET2U	VDET2U×1.025	V
tVREL2         Output delay of release from over-discharge         Vss=3.2V         89         1.28         167         ms           tVREL2         Output delay of release from over-discharge threshold discharge         Vpo-Vc=1.9V         0 3.2V, Vc- volume         0.7         1.2         1.7         ms           VDET2L         CELL2 Over-discharge threshold         Detect falling edge of supply voltage voltage voltage voltage from Over-discharge         Detect rising edge of supply voltage vo				VREL2U×0.975	VREL2U	VREL2U×1.025	V
Vise_12	tVDET2	Output delay of over-discharge	Vss=3.2V	89	128	167	ms
Voetzel Vrelat         CELL2 Over-discharge threshold         Detect falling edge of supply voltage Vrelation (CELL2 Released Voltage from Over-discharge)         Detect rising edge of supply voltage Vrelation (Vrelation Voltage)	tVREL2			0.7	1.2	1.7	ms
VRELZL CALZ Released Voltage from Over-discharge         Detect rising edge of supply voltage values         VRELZL V.0.975         VRELZL VRELZL V.0.955         V VRELZL V.0.955         V VRELZL V.0.975         VDET3 V.0.975	V <sub>DET2L</sub>		Detect falling edge of supply voltage	VDET2L×0.975	V <sub>DET2</sub> L	VDET2L×1.025	V
VDET3	V	CELL2 Released Voltage from Over-	9 9,		VREL2L		٧
tVDET3         Output delay of excess discharge current         VDD-VC=VC-VSs=3.2V, V-0V to 0.5V         8         12         16         ms           tVREL3         Output delay of release from excess discharge-current         VDD-VC=VC-VSs=3.2V, V-0V         0.7         1.2         1.7         ms           VDET4         Excess charge-current threshold         Detect falling edge of 'V-' pin voltage         -0.44         -0.40         -0.36         V-0.23         -0.20         -0.17         V           tVDET4         Output delay of excess charge-current VDD-VC=VC-VSs=3.2V, V-0V to -1V         5         8         11         ms           tVREL4         Output delay of release from excess charge-current VDD-VC=VC-VSs=3.2V, V-0V to -1V         5         8         11         ms           VShort Short protection voltage         VDD-VC=VC-VSs=3.2V, V-0V         0.7         1.2         1.7         ms           Vshort Short protection voltage         VDD-VC=VC-VSs=3.2V         0.7         1.1         1.5         V           Vshort Short protection voltage         VDD-VC=VC-VSs=3.2V, V-10         0.7         1.1         1.5         V           Rshort Reset resistance for Excess discharge-current protection         VDD-VC=VC-VSs=3.2V, V-10         25         40         75         KΩ           VDL1         Nch			Detect rising edge of 'V-' pin voltage	VDET3-0 015	VDET3	VDET3+0 015	V
tVREL3         Output delay of release from excess discharge-current         Vpc-Vc=Vc-Vss=3.2V, V-3V to 0V         0.7         1.2         1.7         ms           VDET4         Excess charge-current threshold         Detect falling edge of 'V-' pin voltage         -0.44         -0.40         -0.36         -0.23         -0.20         -0.17         V           tVDET4         Output delay of excess charge-current tVDD-Vc=Vc-Vss=3.2V, V-9V to -1V         5         8         11         ms           tVREL4         Output delay of release from excess charge-current vDD-Vc=Vc-Vss=3.2V, V-9V to -1V         5         8         11         ms           tVREL4         Output delay of release from excess charge-current vDD-Vc=Vc-Vc-Vss=3.2V, V-9V to -1V         5         8         11         ms           VShort Short protection voltage         VDD-Vc=Vc-Vc-Vss=3.2V, V-9V to -1V         0.7         1.2         1.7         ms           Vshort Short protection voltage         VDD-Vc=Vc-Vc-Vss=3.2V, V-9V to 0.7         1.1         1.5         V           tshort Output Delay of Short protection voltage         VDD-Vc=Vc-Vc-Vss=3.2V, V-1V         25         40         75         kΩ           Rshort discharge-current protection voltage volta	t\/DET3	Output delay of excess discharge	VDD-Vc=Vc-Vss=3.2V,				
V-3V to OV   V-3V to OV to O-1V to OV   V-3V to O-1V to O-1V to OV   V-3V to O-1V to O-1V to O-1V to O-1V to OV   V-3V to O-1V to				0.7	4.0		
VDET4   Excess charge-current threshold   Detect falling edge of 'V-' pin voltage   -0.23   -0.20   -0.17   V	tVREL3			0.7	1.2	1.7	ms
tVDET4         Output delay of excess charge-current         VDD-VC=V <sub>C</sub> -V <sub>SS</sub> =3.2V, V-=0V to -1V         5         8         11         ms           tVREL4         Output delay of release from excess charge-current         VDD-VC=V <sub>C</sub> -V <sub>SS</sub> =3.2V, V-=0V to -1V         5         8         11         ms           VShort         Short protection voltage         VDD-VC=V <sub>C</sub> -V <sub>SS</sub> =3.2V, V-=1V to 0V         0.7         1.2         1.7         ms           Vshort         Short protection voltage         VDD-VC=V <sub>C</sub> -V <sub>SS</sub> =3.2V, V-=1V         0.7         1.1         1.5         V           tshort         Output Delay of Short protection         VDD-VC=V <sub>C</sub> -V <sub>SS</sub> =3.2V, V-=1V         150         300         500         µs           Rshort         Reset resistance for Excess discharge-current protection         VDD-VC=VC-VS=3.2V, V-=1V         25         40         75         kΩ           VDS         Delay Shortening Mode input voltage         VDD-VC=VC-VS=4.0V         -2.2         -1.6         -1.0         V           VOL1         Nch ON voltage of CouT         IDH=-50µA, VDD-VC=VC-VS=3.2V         6.8         7.4         V           VOL2         Nch ON voltage of DouT         IDH=-50µA, VDD-VC=VC-VS=3.2V         ADD-VC=VC-VC-VS=3.2V         6.8         7.4         V           VDD-VC=VC-VS=3.2V				-0.44	-0.40	-0.36	
tVDET4         Output delay of excess charge-current         VDD-VC=VC-VSS=3.2V, V=0V to -1V         5         8         11         ms           tVREL4         Output delay of release from excess charge-current         VDD-VC=VC-VSS=3.2V, V=0V         0.7         1.2         1.7         ms           Vshort         Short protection voltage         VDD-VC=VC-VSS=3.2V, V=1V         0.7         1.1         1.5         V           tshort         Output Delay of Short protection         VDD-VC=VC-VSS=3.2V, V=1V         150         300         500         μs           Rshort         Reset resistance for Excess discharge-current protection         VDD-VC=VC-VSS=3.2V, V=1V         25         40         75         kΩ           VDS         Delay Shortening Mode input voltage         VDD-VC=VC-VSS=4.0V         -2.2         -1.6         -1.0         V           VOL1         Nch ON voltage of Cout         IOL=50μA, VDD-VC=VC-VSS=4.5V         0.4         0.5         V           VOL2         Nch ON voltage of Dout         IOL=50μA, VDD-VC=VC-VSS=3.2V         0.2         0.5         V           VOH2         Pch ON voltage of Dout         IOH=-50μA, VDD-VC=VC-VSS=1.9V         0.2         0.5         V           IDD         Supply current         VDD-VC=VC-VSS=3.2V, V-9V-VC-VC-VSS=3.2V, V-9V-VC-VC-VC-VSS=3.2V	VDET4	Excess charge-current threshold	Detect falling edge of 'V-' pin voltage	-0.23	-0.20	-0.17	V
tVDET4         Output delay of excess charge-current         VDD-VC=VC-VSS=3.2V, V-e0V to -1V         5         8         11         ms           tVREL4         Output delay of release from excess charge-current         VDD-VC=VC-VSS=3.2V, V-e0V         0.7         1.2         1.7         ms           Vshort         Short protection voltage         VDD-VC=VC-VSS=3.2V, V-e0V         0.7         1.1         1.5         V           tshort         Output Delay of Short protection         VDD-VC=VC-VSS=3.2V, V-e0V         150         300         500         µs           Rshort         Reset resistance for Excess discharge-current protection         VDD-VC=VC-VSS=3.2V, V-e1V         25         40         75         kΩ           VD         Delay Shortening Mode input voltage         VDD-VC=VC-VSS=4.0V         -2.2         -1.6         -1.0         V           VOL1         Nch ON voltage of CouT         IOL=50µA, VDD-VC=VC-VSS=3.2V         0.4         0.5         V           VOL2         Nch ON voltage of Dout         IOL=50µA, VDD-VC=VC-VSS=1.9V         0.2         0.5         V           VOH2         Pch ON voltage of Dout         IOH=-50µA, VDD-VC=VC-VSS=3.2V, V-9V-9V-9V-9V-9V-9V-9V-9V-9V-9V-9V-9V-9V							
tVREL4         Output delay of release from excess charge-current         VpD-Vc=Vc-Vss=3.2V, V-=1V to 0V         0.7         1.2         1.7         ms           Vshort         Short protection voltage         VpD-Vc=Vc-Vss=3.2V         0.7         1.1         1.5         V           tshort         Output Delay of Short protection         VpD-Vc=Vc-Vss=3.2V, V-1         150         300         500         µs           Rshort         Reset resistance for Excess discharge-current protection         VpD-Vc=Vc-Vss=3.2V, V-1V         25         40         75         kΩ           VpD-Vc=Vc-Vss=3.2V, V-1V         0.4         0.5         V           VpD-Vc=Vc-Vss=4.5V         0.4         0.5         V           VpD-Vc=Vc-Vss=3.2V         6.8         7.4         V           VpD-Vc=Vc-Vss=3.2V         0.2         0.5         V           VpD-Vc=Vc-Vss=3.2V         0.8         7.4         V           VpD-Vc=Vc-Vss=3.2V         0.8         7.4         V	tVDET4	Output delay of excess charge-current	VDD-VC=VC-VSS=3.2V, V-=0V to -1V	5			ms
tVREL4         charge-current         V-=-1V to 0V         0.7         1.2         1.7         ms           Vshort         Short protection voltage         Vpd-Vc=Vc-Vss=3.2V         0.7         1.1         1.5         V           tshort         Output Delay of Short protection         Vpd-Vc=Vc-Vss=3.2V         150         300         500         μs           Rshort         Reset resistance for Excess discharge-current protection         Vpd-Vc=Vc-Vss=3.2V         25         40         75         kΩ           Vbs         Delay Shortening Mode input voltage         Vpd-Vc=Vc-Vss=4.0V         -2.2         -1.6         -1.0         V           Vol.1         Nch ON voltage of Cour         Nch ON voltage of Dour				0.7	4.0	4 7	
Vshort         Short protection voltage         Vpd-Vc=Vc-Vss=3.2V         0.7         1.1         1.5         V           tshort         Output Delay of Short protection         Vpd-Vc=Vc-Vss=3.2V, V=1V         150         300         500         µs           Rshort         Reset resistance for Excess discharge-current protection         Vpd-Vc=Vc-Vss=3.2V, V=1V         25         40         75         kΩ           Vps         Delay Shortening Mode input voltage         Vpd-Vc=Vc-Vss=4.0V         -2.2         -1.6         -1.0         V           Vol.1         Nch ON voltage of Cout         Iol=50µA, Vpd-Vc=Vc-Vss=4.5V         0.4         0.5         V           Voh1         Pch ON voltage of Cout         Ioh=-50µA, Vpd-Vc=Vc-Vss=3.2V         6.8         7.4         V           Voh2         Nch ON voltage of Dout         Ioh=-50µA, Vpd-Vc=Vc-Vss=1.9V         0.2         0.5         V           Voh2         Pch ON voltage of Dout         Ioh=-50µA, Vpd-Vc=Vc-Vss=3.2V, Vss=3.2V         6.8         7.4         V           Idage of Dout         Vpd-Vc=Vc-Vss=3.2V, Vss=3.2V         4.0         8.0         µA				0.7	1.2	1.7	ms
tshort         Output Delay of Short protection         VDD-VC=VC-Vs=3.2V, V-90 v to 6.4V         150         300         500         μs           Rshort         Reset resistance for Excess discharge-current protection         VDD-VC=VC-Vss=3.2V, V-1V         25         40         75         kΩ           VDS         Delay Shortening Mode input voltage         VDD-VC=VC-Vss=4.0V         -2.2         -1.6         -1.0         V           VOL1         Nch ON voltage of CouT         IOL=50μA, VDD-Vc=Vc-Vss=4.5V         0.4         0.5         V           VOH1         Pch ON voltage of CouT         IOH=-50μA, VDD-Vc=Vc-Vss=3.2V         6.8         7.4         V           VOL2         Nch ON voltage of DouT         IOH=-50μA, VDD-Vc=Vc-Vss=1.9V         0.2         0.5         V           VOH2         Pch ON voltage of DouT         IOH=-50μA, VDD-Vc=Vc-Vc-Vss=3.2V         6.8         7.4         V           IDD         Supply current         VDD-Vc=Vc-Vss=3.2V, V-90V         4.0         8.0         μΑ				0.7	1.1	1.5	V
Rshort         Reset resistance for Excess discharge-current protection         Vpd-Vc=Vc-Vss=3.2V, V-=1V         25         40         75         kΩ           Vbs         Delay Shortening Mode input voltage         Vpd-Vc=Vc-Vss=4.0V         -2.2         -1.6         -1.0         V           Vol.1         Nch ON voltage of Cout         Iol=50μA, Vpd-Vc=Vc-Vss=4.5V         0.4         0.5         V           Voh1         Pch ON voltage of Cout         Ioh=-50μA, Vpd-Vc=Vc-Vss=3.2V         6.8         7.4         V           Vol.2         Nch ON voltage of Dout         Iol=50μA, Vpd-Vc=Vc-Vss=1.9V         0.2         0.5         V           Voh2         Pch ON voltage of Dout         Ioh=-50μA, Vpd-Vc=Vc-Vss=3.2V         Vpd-Vc=Vc-Vc-Vss=3.2V         6.8         7.4         V           Ibb         Supply current         Vpd-Vc=Vc-Vss=3.2V, V-e0V         4.0         8.0         μA			VDD-VC=VC-Vss=3.2V,				
VDS         Delay Shortening Mode input voltage         VDD-Vc=Vc-Vss=4.0V         -2.2         -1.6         -1.0         V           VOL1         Nch ON voltage of CouT         IoL=50μA, VDD-Vc=Vc-Vss=4.5V         0.4         0.5         V           VOH1         Pch ON voltage of CouT         IoH=-50μA, VDD-Vc=Vc-Vss=3.2V         6.8         7.4         V           VOL2         Nch ON voltage of DouT         IoL=50μA, VDD-Vc=Vc-Vss=1.9V         0.2         0.5         V           VOH2         Pch ON voltage of DouT         IOH=-50μA, VDD-Vc=Vc-Vc-Vss=3.2V         6.8         7.4         V           IDD         Supply current         VDD-Vc=Vc-Vss=3.2V, V-90V         4.0         8.0         μΑ	Rshort			25	40	75	kΩ
Vol.1         Nch ON voltage of Cout         IoL=50μA, VDD-Vc=Vc-Vss=4.5V         0.4         0.5         V           VoH1         Pch ON voltage of Cout         IoH=-50μA, VDD-Vc=Vc-Vss=3.2V         6.8         7.4         V           VoL2         Nch ON voltage of Dout         IoL=50μA, VDD-Vc=Vc-Vss=1.9V         0.2         0.5         V           VoH2         Pch ON voltage of Dout         IoH=-50μA, VDD-Vc=Vc-Vc-Vss=3.2V         6.8         7.4         V           IDD         Supply current         VDD-Vc=Vc-Vss=3.2V, V-90V         4.0         8.0         μA	Vne		Vpp-Vc=Vc-Vss=4 0V	-22	-1 6	-1 0	V
VOH1         Pch ON voltage of Cout         IOH=-50μA, VDD-Vc=Vc-Vss=3.2V         6.8         7.4         V           VOL2         Nch ON voltage of Dout         IOL=50μA, VDD-Vc=Vc-Vss=1.9V         0.2         0.5         V           VOH2         Pch ON voltage of Dout         IOH=-50μA, VDD-Vc=Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-V			Iol=50µA,	<i>L.L</i>			
Vol.2         Nch ON voltage of Dout         IoL=50μA, VDD-Vc=Vc-Vss=1.9V         0.2         0.5         V           VoH2         Pch ON voltage of Dout         IoH=-50μA, VDD-Vc=Vc-Vc-Vss=3.2V         6.8         7.4         V           IDD         Supply current         VDD-Vc=Vc-Vss=3.2V, V-90V         4.0         8.0         μA			Іон=-50µА,	6.8			V
Von-Vc=Vc-Vss=1.9V         Von-Vc=Vc-Vss=1.9V           VoH2         Pch ON voltage of Dout         IoH=-50μA, VDD-Vc=Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-V	Vol2	Nch ON voltage of Dout	ΙοL=50μΑ,		0.2	0.5	V
VoH2         Pch ON Voltage of Dout         Vss=3.2V         6.8         7.4         V           IDD         Supply current         VDD-Vc=Vc-Vss=3.2V, V-=0V         4.0         8.0         μA							
V-=0V 4.0 8.0 μA	Voh2	Pch ON voltage of Dout	Vss=3.2V	6.8	7.4		V
Is Standby current VDD-Vc=Vc-Vss=1.9V 1.2 2.0 μA		* * *	V-=0V				
	ls	Standby current	VDD-Vc=Vc-Vss=1.9V		1.2	2.0	μA

\*Note: We compensate for this characteristic related to temperature by laser-trim, however, this specification is guaranteed by design, not production tested.



### R5460x2xxAC version

Unless otherwise specified, Ta=25°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V <sub>DD1</sub>	Operating input voltage	Voltage defined as VDD-Vss	1.50	71	10.0	V
Vst	Minimum operating Voltage for 0V charging	Voltage defined as VDD-V- VDD-Vss=0V			1.8	V
	CELL1 Over-charge threshold	Detect rising edge of supply voltage R1=330 $\Omega$ R1=330 $\Omega$ (Ta=-5 to 55°C)'Note	VDET1U-0.025 VDET1U-0.030	VDET1U VDET1U	VDET1U+0.025 VDET1U+0.030	V
VREL1U	CELL1 Over-charge released voltage	R1=330Ω	VREL1U-0.05	V <sub>REL1U</sub>	VREL1U+0.05	V
tV <sub>DET1</sub>	Output delay of over-charge	VDD=3.2V to 4.5V, Vc-Vss=3.2V	0.7	1.0	1.3	S
tV <sub>REL1</sub>	Output delay of release from over-charge	VDD=4.5V to 3.2V, Vc-Vss=3.2V	11	16	21	ms
	CELL2 Over-charge detector threshold	Detect rising edge of supply voltage $R2=330\Omega$ $R2=330\Omega$ (Ta=-5 to 5°C)'Note	VDET1L-0.025 VDET1L-0.030	VDET1L VDET1L	VDET1L+0.025 VDET1L+0.030	V
$V_{REL1L}$	CELL2 Over-charge released voltage	R2=330Ω	VREL1L-0.050	VREL1L	VREL1L+0.050	V
VDET2U	CELL1 Over-discharge threshold	Detect falling edge of supply voltage	VDET2U×0.975	VDET2U	VDET2U×1.025	V
tV <sub>DET2</sub>	Output delay of over-discharge	V <sub>DD</sub> -V <sub>C</sub> =3.2V to 1.9V V <sub>C</sub> - V <sub>SS</sub> =3.2V	89	128	167	ms
tVREL2	Output delay of release from over- discharge	V <sub>DD</sub> -V <sub>C</sub> =1.9V to 3.2V V <sub>C</sub> - V <sub>SS</sub> =3.2V	0.7	1.2	1.7	ms
V <sub>DET2</sub> L	CELL2 Over-discharge threshold	Detect falling edge of supply voltage	VDET2L×0.975	VDET2L	VDET2L×1.025	V
	Excess discharge-current threshold	Detect rising edge of 'V-' pin voltage	VDET3-0.015	V <sub>DET3</sub>	VDET3+0.015	V
tV <sub>DET3</sub>	Output delay of excess discharge current	V <sub>DD</sub> -V <sub>C</sub> =V <sub>C</sub> -Vss=3.2V, V-=0V to 0.5V	8	12	16	ms
tVREL3	Output delay of release from excess discharge-current	V <sub>DD</sub> -V <sub>C</sub> =V <sub>C</sub> -V <sub>SS</sub> =3.2V, V-=3V to 0V	0.7	1.2	1.7	ms
			-0.44	-0.40	-0.36	
VDET4	Excess charge-current threshold	Detect falling edge of 'V-' pin voltage	-0.23	-0.20	-0.17	V
			-0.13	-0.10	-0.07	
tVDET4	Output delay of excess charge-current	VDD-Vc=Vc-Vss=3.2V, V-=0V to -	5	8	11	ms
tVREL4	Output delay of release from excess charge-current	V <sub>DD</sub> -V <sub>C</sub> =V <sub>C</sub> -V <sub>SS</sub> =3.2V, V-=-1V to 0V	0.7	1.2	1.7	ms
Vshort	Short protection voltage	VDD-VC=VC-Vss=3.2V	0.7	1.1	1.5	V
	Output Delay of Short protection	V <sub>DD</sub> -V <sub>C</sub> =V <sub>C</sub> -V <sub>SS</sub> =3.2V, V-=0V to 6.4V	150	300	500	μs
Rshort	Reset resistance for Excess discharge-current protection	VDD-VCC=VC-VSS=3.2V, V-=1V	25	40	75	kΩ
VDS	Delay Shortening Mode input voltage	V <sub>DD</sub> -V <sub>C</sub> =V <sub>C</sub> -V <sub>SS</sub> =4.0V	-2.2	-1.6	-1.0	V
V <sub>OL1</sub>	Nch ON voltage of Cout	IOL=50µA VDD-VC=VC-VSS=4.5V		0.4	0.5	V
Voн1	Pch ON voltage of Cout	IOH=-50µA VDD-VC=VC-Vss=3.2V	6.8	7.4		V
V <sub>OL2</sub>	Nch ON voltage of Dout	IoL=50µA VDD-VC=VC-Vss=1.9V		0.2	0.5	V
V <sub>OH2</sub>	Pch ON voltage of Douт	IOH=-50µA, VDD-VC=VC- Vss=3.2V	6.8	7.4		V
IDD	Supply current	VDD-VC=VC-Vss=3.2V, V-=0V		4.0	8.0	μA
Is	Standby current	V <sub>DD</sub> -V <sub>C</sub> =V <sub>C</sub> -V <sub>S</sub> s=1.9V			0.1	μA

\*Note: We compensate for this characteristic related to temperature by laser-trim, however, this specification is guaranteed by design, not production tested.

NO.EA-165-160603

R5460x2xxAF version

Unless otherwise specified, Ta=25°C

Symbol	Officas O	therwise specified, ra=25 C	I			T	т
Vertical   Vertica	Symbol	Item	Conditions	Min.	Тур.	Max.	Uni t
Carried   Car			Voltage defined as VDD-VSS	1.5		10.0	V
	Vst		· ·			1.8	V
Victor   Output delay of over-charge   Vob-3.2V to 4.5V, Vc-Vss=3.2V   0.7   1.0   1.3   s	VDET1U	CELL1 Over-charge threshold	R1=330Ω		_		V
tVRELT         Output delay of release from over-charge         Vob=4.5V to 3.2V, Vc-Vss=3.2V         11         16         21         rr s           VDETIL         CELL2 Over-charge detector threshold R2=330Ω         Detect rising edge of supply voltage         VDETIL	$V_{REL1U}$	CELL1 Over-charge released voltage	R1=330Ω	VREL1U-0.05	VREL1U	VREL1U+0.05	V
Votatic   Cell   Cover-charge   Cell   C	$tV_{DET1}$	Output delay of over-charge	VDD=3.2V to 4.5V, Vc-Vss=3.2V	0.7	1.0	1.3	S
Votable   Vota	tVREL1		V <sub>DD</sub> =4.5V to 3.2V, V <sub>C</sub> -V <sub>SS</sub> =3.2V	11	16	21	m s
Voet2u   CELL1 Over-discharge threshold   Detect falling edge of supply voltage   Voet2u   Voet2ux1.025   Voet2u   Voet2ux1.025   Voet2u   Voet2ux1.025		-	R2=330Ω	VDET1L-0.030		VDET1L+0.030	V V
VRELZU   CELL1 Released Voltage from Over-discharge   Detect rising edge of supply voltage   VRELZU \ VRELZU	$V_{REL1L}$	CELL2 Over-charge released voltage		VREL1L-0.050	VREL1L	VREL1L+0.050	V
Voltage   Volt	V <sub>DET2U</sub>	CELL1 Over-discharge threshold	Detect falling edge of supply voltage	VDET2U×0.975	VDET2U	VDET2U×1.025	V
Vocation	VREL2U		Detect rising edge of supply voltage	VREL2U×0.975	V <sub>REL2U</sub>	VREL2U×1.025	V
Viscout   Visc	tVDET2	Output delay of over-discharge		89	128	167	m s
Voet24   CELL2 Over-discharge threshold   Detect falling edge of supply voltage   Voet24x0.975   Voet24x1.025	tV <sub>REL2</sub>			0.7	1.2	1.7	m s
VREL2L CELL2 Released Voltage from Over-discharge         Detect rising edge of supply voltage         VREL2L VREL2L×1.025         V REL2L×1.025         V REL2L×2.025         V R				VDET2L×0.975	VDET2L	VDET2L×1.025	V
VDET3		CELL2 Released Voltage from Over-					V
tVDETS         Output delay of excess discharge current         VDD-VC=VC-VSs=3.2V, V-=0V to 0.5V         8         12         16         m s           tVREL3         Output delay of release from excess discharge-current         VDD-VC=VC-VSs=3.2V, V-9V to 0.7         0.7         1.2         1.7         m s           VDET4         Excess charge-current threshold         Detect falling edge of 'V-' pin voltage         -0.44         -0.40         -0.36         V-9.00         -0.13         -0.10         -0.07         V           tVDET4         Output delay of excess charge-current         VDD-VC=VC-VSs=3.2V, V-90V to -1V         5         8         11         m           tVREL4         Output delay of release from excess charge-current         VDD-VC=VC-VSs=3.2V, V-90V to -1V         5         8         11         m           vShort Short protection voltage         VDD-VC=VC-VSs=3.2V, V-90V to 0.7         1.2         1.7         m           vShort Short protection voltage         VDD-VC=VC-VSs=3.2V, V-90V to 6.4VV         150         300         500         ps           Reset resistance for Excess discharge-current protection         VDD-VC=VC-VSs=3.2V, V-90V to 6.4VV         25         40         75         kg           Vos Delay Shortening Mode input voltage         VDD-VC=VC-VSs=4.0V         -2.2         -1.6         -1.0 <td>V<sub>DET3</sub></td> <td></td> <td>Detect rising edge of 'V-' pin voltage</td> <td>VDET3-0.015</td> <td>V<sub>DET3</sub></td> <td>VDET3+0.015</td> <td>V</td>	V <sub>DET3</sub>		Detect rising edge of 'V-' pin voltage	VDET3-0.015	V <sub>DET3</sub>	VDET3+0.015	V
tVREL3         Output delay of release from excess discharge-current         VDD-VC=VC-Vss=3.2V, V-3V to 0V         0.7         1.2         1.7         m s           VDET4         Excess charge-current threshold         Detect falling edge of 'V-' pin voltage         -0.44         -0.40         -0.36         -0.23         -0.20         -0.17         V           tVDET4         Output delay of excess charge-current         VDD-VC=VC-Vss=3.2V, V-90V to -1V         5         8         11         m s           tVREL4         Output delay of release from excess charge-current         VDD-VC=VC-Vss=3.2V, V-90V to -1V         5         8         11         m s           VShort Short protection voltage         VDD-VC=VC-Vss=3.2V, V-90V to 0.7         1.2         1.7         m s           Vshort Short protection voltage         VDD-VC=VC-Vss=3.2V, V-90V to 6.4VV         150         300         500         μs           Rshort Reset resistance for Excess discharge-current protection         VDD-VC=VC-Vss=3.2V, V-91V         25         40         75         Ks           VDS Delay Shortening Mode input voltage         VDD-VC=VC-Vss=4.0V         -2.2         -1.6         -1.0         V           VOL1 Nch ON voltage of Cour         IDH-50µA VDD-VC=VC-Vss=3.2V         6.8         7.4         V           VOL2 Nch ON voltage of Dour <td></td> <td>Output delay of excess discharge</td> <td>V<sub>DD</sub>-V<sub>C</sub>=V<sub>C</sub>-V<sub>SS</sub>=3.2V,</td> <td></td> <td></td> <td></td> <td>m s</td>		Output delay of excess discharge	V <sub>DD</sub> -V <sub>C</sub> =V <sub>C</sub> -V <sub>SS</sub> =3.2V,				m s
VDET4   Excess charge-current threshold   Detect falling edge of 'V-' pin voltage   -0.44   -0.40   -0.36   -0.23   -0.20   -0.17   V	tVREL3	Output delay of release from	VDD-VC=VC-VSS=3.2V,	0.7	1.2	1.7	m s
tVrelated Output delay of excess charge-current Vriderated Policy of the ease from excess charge-current Vriderated Policy of the ease from excess charge-current Vriderated Policy of the ease from excess charge-current Vriderated Policy of Short protection voltage Vriderated Policy of Short protection Vriderated Policy of Short Policy of Sh	V <sub>DET4</sub>			-0.23	-0.20	-0.17	V
VShort         Short protection voltage         V-=-1V to 0V         0.7         1.2         1.7         s           VShort         Short protection voltage         VDD-VC=VC-VSS=3.2V         0.7         1.1         1.5         V           tshort         Output Delay of Short protection         VDD-VC=VC-VSS=3.2V         150         300         500         µs           Rshort         Reset resistance for Excess discharge-current protection         VDD-VC=VC-VSS=3.2V         V-=1V         25         40         75         KS           VDD-VC=VC-VSS=4.0V         -2.2         -1.6         -1.0         V           VOL1         Nch ON voltage of Cout         IOL=50µA VDD-VC=VC-VSS=4.5V         0.4         0.5         V           VOL2         Nch ON voltage of Cout         IOH=-50µA VDD-VC=VC-VSS=3.2V         6.8         7.4         V           VOH2         Pch ON voltage of Dout         IOH=-50µA, VDD-VC=VC-VSS=3.2V         6.8         7.4         V           IDD         Supply current         VDD-VC=VC-VSS=3.2V V-=0V         4.0         8.0         µ/	tVDET4	Output delay of excess charge-current	VDD-VC=VC-VSS=3.2V, V-=0V to -1V	5	8	11	m s
tshort         Output Delay of Short protection         VDD-VC=VC-Vss=3.2V, V-9V to 6.4VV         150         300         500         µst           Rshort         Reset resistance for Excess discharge-current protection         VDD-VC=VC-Vss=3.2V, V-9V         25         40         75         kst           VDD-VC=VC-Vss=4.5V         -2.2         -1.6         -1.0         V           VOH1         Pch ON voltage of Cout         IOH=-50µA VDD-VC=Vc-Vss=3.2V         6.8         7.4         V           VOH2         Pch ON voltage of Dout         IOH=-50µA, VDD-VC=Vc-Vss=3.2V         6.8         7.4         V           IDD         Supply current         VDD-VC=Vc-Vss=3.2V V-9V         4.0         8.0         µV	tVREL4		· ·	0.7	1.2	1.7	m s
tshort         Output Delay of Short protection         VDD-VC=VC-Vss=3.2V, V-90 to 6.4VV         150         300         500         µst           Rshort         Reset resistance for Excess discharge-current protection         VDD-VC=VC-Vss=3.2V, V-91 V         25         40         75         kg           VDD-VC=VC-Vss=4.5V         -2.2         -1.6         -1.0         V           VDH1         Nch ON voltage of Cout         IOL=50µA VDD-VC=Vc-Vss=4.5V         0.4         0.5         V           VOL2         Nch ON voltage of Dout         IOL=50µA VDD-VC=Vc-Vss=3.2V         6.8         7.4         V           VOH2         Pch ON voltage of Dout         IOH=-50µA, VDD-VC=Vc-Vc-Vss=3.2V         6.8         7.4         V           IDD         Supply current         VDD-VC=Vc-Vss=3.2V V-90V         4.0         8.0         µ/V	Vshort	Short protection voltage	VDD-VC=VC-VSS=3.2V	0.7	1.1	1.5	V
Rshort         Reset resistance for Excess discharge-current protection         VDD-VC=VC-VSS=3.2V, V-=1V         25         40         75         KC           VDS         Delay Shortening Mode input voltage         VDD-VC=VC-VSS=4.0V         -2.2         -1.6         -1.0         V           VOL1         Nch ON voltage of Cout         IOL=50µA VDD-VC=VC-VSS=4.5V         0.4         0.5         V           VOH1         Pch ON voltage of Cout         IOH=-50µA VDD-VC=VC-VSS=3.2V         6.8         7.4         V           VOH2         Nch ON voltage of Dout         IOH=-50µA VDD-VC=VC-VSS=1.9V         0.2         0.5         V           VOH2         Pch ON voltage of Dout         IOH=-50µA, VDD-VC=VC-VC-VC-VC-VC-VC-VC-VC-VC-VC-VC-VC-VC-V			VDD-VC=Vc-Vss=3.2V,	150	300	500	μs
VDS         Delay Shortening Mode input voltage         VDD-VC=VC-VSs=4.0V         -2.2         -1.6         -1.0         V           VOL1         Nch ON voltage of Cout         IoL=50µA VDD-VC=VC-VSs=4.5V         0.4         0.5         V           VOH1         Pch ON voltage of Cout         IoH=-50µA VDD-VC=VC-VSs=3.2V         6.8         7.4         V           VOL2         Nch ON voltage of Dout         IoL=50µA VDD-VC=VC-VSs=1.9V         0.2         0.5         V           VOH2         Pch ON voltage of Dout         IOH=-50µA, VDD-VC=VC-VC-VC-VC-VC-VC-VC-VC-VC-VC-VC-VC-VC-V	Rshort			25	40	75	kΩ
Vol.1         Nch ON voltage of Cout         IoL=50μA Vdd-Vc=Vc-Vss=4.5V         0.4         0.5         V           VoH1         Pch ON voltage of Cout         IoH=-50μA Vdd-Vc=Vc-Vss=3.2V         6.8         7.4         V           Vol.2         Nch ON voltage of Dout         IoL=50μA Vdd-Vc=Vc-Vss=1.9V         0.2         0.5         V           VoH2         Pch ON voltage of Dout         IoH=-50μA, Vdd-Vc=Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-V	Vos		V <sub>DD</sub> -V <sub>C</sub> =V <sub>C</sub> -V <sub>SS</sub> =4.0V	-2.2	-1.6	-1.0	V
VoH1         Pch ON voltage of Cout         IoH=-50μA Vdd-Vc=Vc-Vss=3.2V         6.8         7.4         V           VoL2         Nch ON voltage of Dout         IoL=50μA Vdd-Vc=Vc-Vss=1.9V         0.2         0.5         V           VoH2         Pch ON voltage of Dout         IoH=-50μA, Vdd-Vc=Vc-Vc-Vss=3.2V         6.8         7.4         V           Idd         Supply current         Vdd-Vc=Vc-Vss=3.2V V-=0V         4.0         8.0         μ/							V
Vol.2         Nch ON voltage of Dout         IoL=50μA Vdd-Vc=Vc-Vss=1.9V         0.2         0.5         V           VoH2         Pch ON voltage of Dout         IoH=-50μA, Vdd-Vc=Vc-Vc-Vss=3.2V         6.8         7.4         V           Idd         Supply current         Vdd-Vc=Vc-Vss=3.2V V-=0V         4.0         8.0         μ/				6.8		-	V
VOH2         Pch ON voltage of Dout         IOH=-50µA, VDD-Vc=Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-Vc-V						0.5	V
IDD Supply current VDD-Vc=Vc-Vss=3.2V V-=0V 4.0 8.0 μ/		Ĭ	Iон=-50µA, VDD-Vc=Vc-	6.8			V
	IDD	Supply current			4.0	8.0	μΑ
							μΑ

\*Note: We compensate for this characteristic related to temperature by laser-trim, however, this specification is guaranteed by design, not production tested.

### OPERATION

#### ● VDET1U, VDET1L / Over-Charge Detectors

The VDET1U and VDET1L monitor the voltage between VDD pin and Vc pin (the voltage of Cell1) and the voltage between Vc pin and Vss pin (the voltage of Cell2), if either voltage becomes equal or more than the over-charge detector threshold, the over-charge is detected, and an external charge control Nch MOSFET turns off with Cout pin being at "L" level.

VDET1U is the detector of Cell1, and the VDET1L is the detector of Cell2.

To reset the over-charge and make the Cout pin level to "H" again after detecting over-charge, in such conditions that a time when the both Cell1 and Cell2 are down to a level lower than over-charge voltage, by connecting a kind of load to Vdd after disconnecting a charger from the battery pack. Then, the output voltage of Cout pin becomes "H" and it makes an external Nch MOSFET turn on, and charge cycle is available. In case of the charger is continuously connected and over-charge is detected, both battery voltages of Cell1 and Cell2 become lower than the released voltage from over-charge, charge becomes possible. Therefore there is a specific hysteresis for over-charge detectors. To judge whether or not load is connected, the built-in excess-discharge current detector is used. By connecting some load, V- pin voltage becomes equal or more than excess-discharge current detector threshold, and reset the over-charge detecting state.

Further, either or both voltage of Cell1 and Cell2 is higher than the over-charge detector threshold, if a charger is removed and some load is connected, Cout outputs "L", however, load current can flow through the parasitic diode of the external charge control Nch MOSFET. After that, when both voltages of Cell1 and Cell2 become lower than the over-charge detector threshold, Cout becomes "H".

Internal fixed output delay times for over-charge detection and release from over-charge exist. If either or both of the voltage of Cell1 or Cell2 keeps its level more than the over-charge detector threshold, and output delay time passes, over-charge voltage is detected. Even when the voltage of Cell1 or Cell2 pin level becomes equal or higher level than VDET1 if these voltages would be back to a level lower than the over-charge detector threshold within a time period of the output delay time, the over-charge is not detected. Besides, after detecting over-charge, while the both of Cell1 and Cell2 voltages are lower than the over-charge detector threshold, even if a charger is removed and a load is connected, if the voltage is recovered within output delay time of release from over-charge, over-charge state is not released.

A level shifter incorporated in a buffer driver for the Cout pin makes the "L" level of Cout pin to the V - pin voltage and the "H" level of Cout pin is set to VDD voltage with CMOS buffer.

### ● VDET2U, VDET2L / Over-Discharge Detectors

The VDET2U and VDET2L monitor the voltage between VDD pin and VC pin (Cell1 voltage) and the voltage between VC pin and VSS pin (Cell2 voltage). When either of the cell1 or cell2 voltage becomes equal or less than the over-discharge detector threshold, the over-discharge is detected and discharge stops by the external discharge control Nch MOSFET turning off with the DOUT pin being at "L" level.

The conditions to release over-discharge voltage detector after detecting over-discharge voltage are as follows:

A/D versions: after connecting a charger, when the cell voltage becomes higher than over-discharge detector threshold or, without connecting charger, when the cell voltage becomes equal or higher than over-discharge released voltage.

C version: after connecting a charger, when the cell voltage becomes higher than over-discharge detector threshold voltage.

E version: whether connecting a charger, or not, when the cell voltage becomes higher than released voltage from overdischarge.

F version: after connecting a charger, when the cell voltage becomes higher than released voltage from over-discharge.

In case that connecting a charger, for A/C/D versions, there is no hysteresis for over-discharge detector. For E/F versions, even if a charger is connected to the battery pack, the hysteresis of over-discharge detector exists.

When a cell voltage equals to zero, if the voltage of a charger is equal or more than 0V-charge minimum voltage (Vst), Cour pin becomes "H" and a system is allowable to charge.

The output delay time for over-discharge detect is fixed internally. Even if either voltage of Cell1 or Cell2 is down to equal or lower than the over-discharge detector threshold, if the both voltages of Cell1 or Cell2 would be back to a level higher than the over-discharge detector threshold within a time period of the output delay time, the over-discharge is not detected. Output delay time for release from over-discharge is also set.

After detecting over-discharge, supply current would be reduced and be into standby by halting unnecessary circuits and

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consumption current of the IC itself is made as small as possible.

C/F version: after detecting over-discharge, all the circuits are halted and the R5460 will be into standby mode.

Others: after detecting over-discharge, whole circuits except over-discharge released detector function are halted, and the R5460 will be into standby mode.

The output type of Dout pin is CMOS having "H" level of VDD and "L" level of Vss.

### ● VDET3 /Excess discharge-current Detector, Short Circuit Protector

Both of the excess current detector and short circuit protection can work when the both of control FETs are in "ON" state.

When the V- pin voltage is up to a value between the short protection voltage (Vshort) and excess discharge-current threshold VDET3, VDET3 operates and further soaring of V- pin voltage higher than Vshort makes the short circuit protector enabled. This leads the external discharge control Nch MOSFET turns off with the Dout pin being at "L" level.

An output delay time for the excess discharge-current detector is internally fixed.

A quick recovery of V- pin level from a value between Vshort and V<sub>DET3</sub> within the delay time keeps the discharge control FET staying "H" state. Output delay time for Release from excess discharge-current detection is also set.

When the short circuit protector is enabled, the Dout would be "L" and the delay time is also set.

The V- pin has a built-in pull-down resistor to the Vss pin, that is, the resistance to release from excess-discharge current.

After an excess discharge-current or short circuit protection is detected, removing a cause of excess discharge-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 Vss level through the built-in pulled down resistor. The reset resistor of excess discharge-current is off at normal state. Only when detecting excess discharge-current or short circuit, the resistor is on.

Output delay time of excess discharge-current is set shorter than the delay time for over-discharge detector. Therefore, if VDD voltage would be lower than VDET2 at the same time as the excess discharge-current is detected, the R5460x is at excess discharge-current detection mode. By disconnecting a load, VDET3 is automatically released from excess discharge-current.

### ● VDET4/ Excess charge-current detector

When the battery pack is chargeable and discharge is also possible, V<sub>DET4</sub> senses V- pin voltage. For example, in case that a battery pack is charged by an inappropriate charger, an excess current flows, then the voltage of V- pin becomes equal or less than excess charge-current detector threshold. Then, the output of C<sub>OUT</sub> becomes "L", and prevents from flowing excess current in the circuit by turning off the external Nch MOSFET.

Output delay of excess charge current is internally fixed. Even the voltage level of V- pin becomes equal or lower than the excess charge-current detector threshold, the voltage is higher than the VDET4 threshold within the delay time, the excess charge current is not detected. Output delay for the release from excess charge current is also set.

VDET4 can be released with disconnecting a charger and connecting a load.

### • DS (Delay Shorten) function

Output delay time of over-charge, over-discharge can be shorter than those setting value by forcing equal or less than the delay shortening mode voltage to V- pin when the Cout is "H".

### Operation against 2-Cell Unbalance

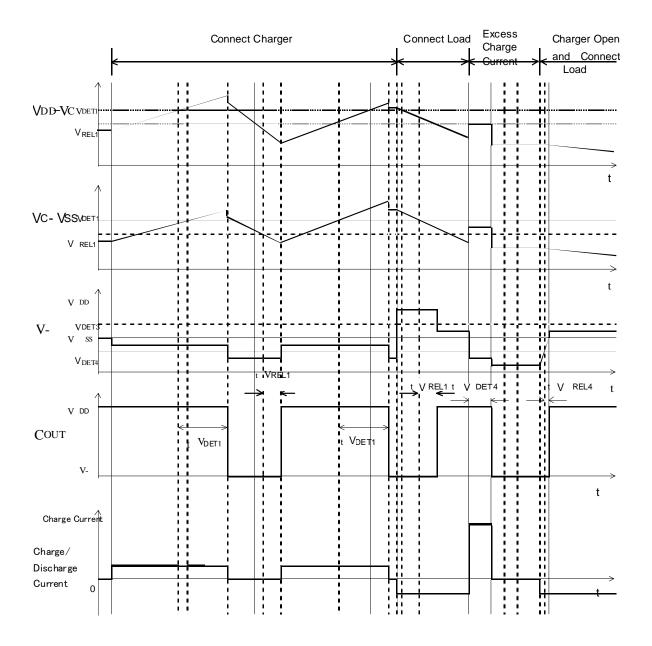
A/D/E version: If one of the cells detects over-charge and the output of Cout becomes "L" and keeps the status, even if the other cell detects over-charge or over-discharge or short, the over-charge status is maintained and the output of Cout keeps "L". If one of the cell detects over-charge and the output of Cout becomes "L", the other cell detects over-discharge and the former cell is released from over-charge, after the delay time of the released from over-charge, the output of Cout becomes "H", and after the delay time of detecting over-discharge, the output of Dout becomes "L". After detecting over-discharge, A/D/E version halts internal unnecessary circuits and be into the standby mode. (Supply current Max. 2.0µA)

C/F version: If one of the cells detects over-charge, and when the Cout becomes "L", even if the other cell would detect over-discharge or short, the over-charge detector will be dominant and Cout keeps the "L" level. If one of the cell detects the over-discharge, and when the Dout becomes "L", in case that a charger is connected to the battery pack and the other cell detects over-charge, the internal counter will start and after the delay time of over-discharge detector, Dout will become "H". After the delay time of over-charge release from when the internal counter starts, Cout will be "L". If the over-discharge is detected, internal unnecessary circuits will be cut off and the standby mode will be realized. (Standby current Max. 0.1µA) In any versions, the external FETs do not turn off at the same time.



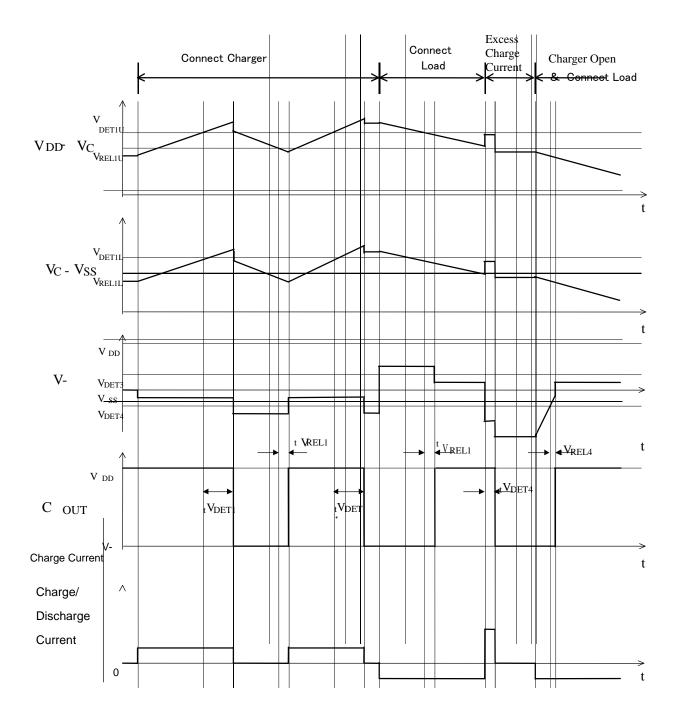
# **TIMING CHART**

(1) Timing diagram of Over-charge, Excess charge current AA/AC/AD version  $\,$ 

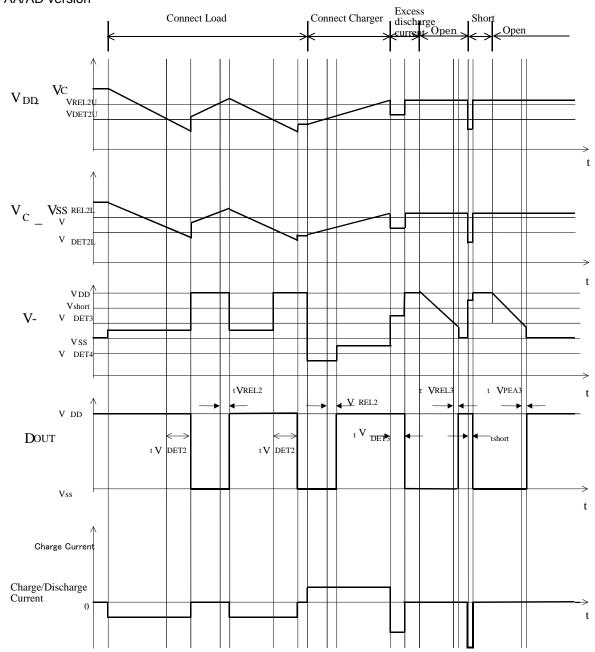


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AE / AF version

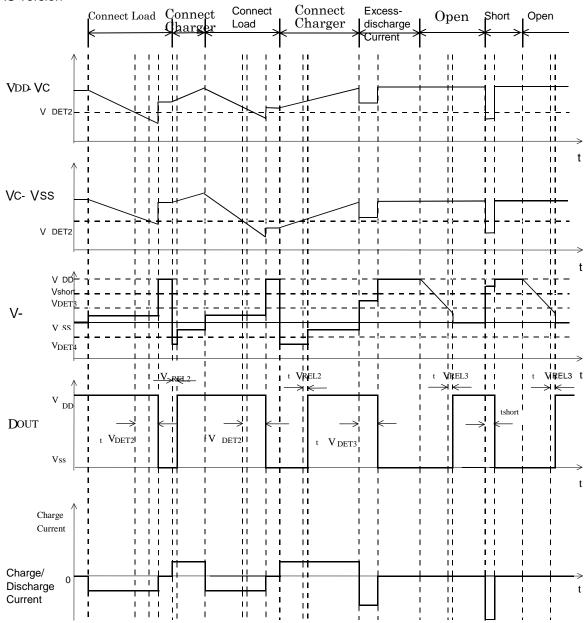


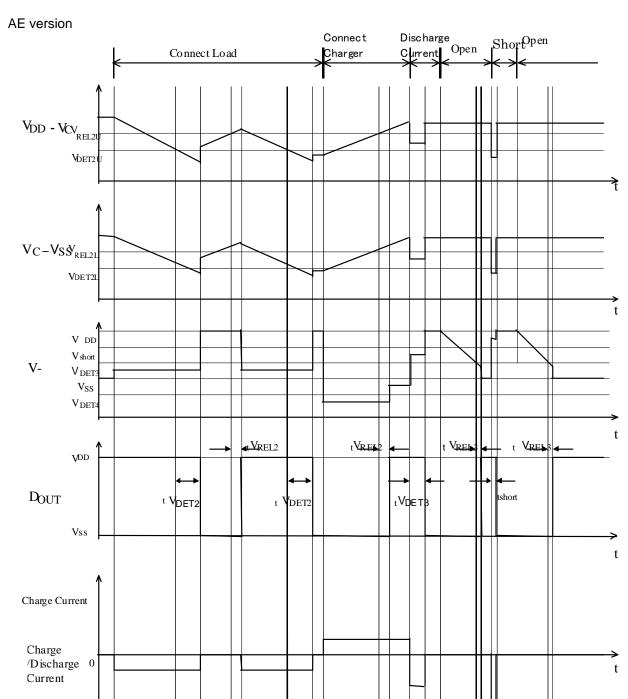
# (2) Over-discharge, Excess discharge current, short circuit AA/AD version



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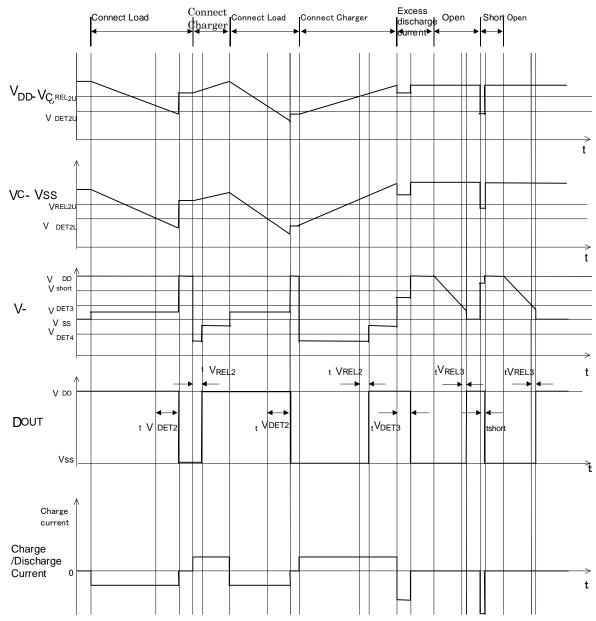
AC version



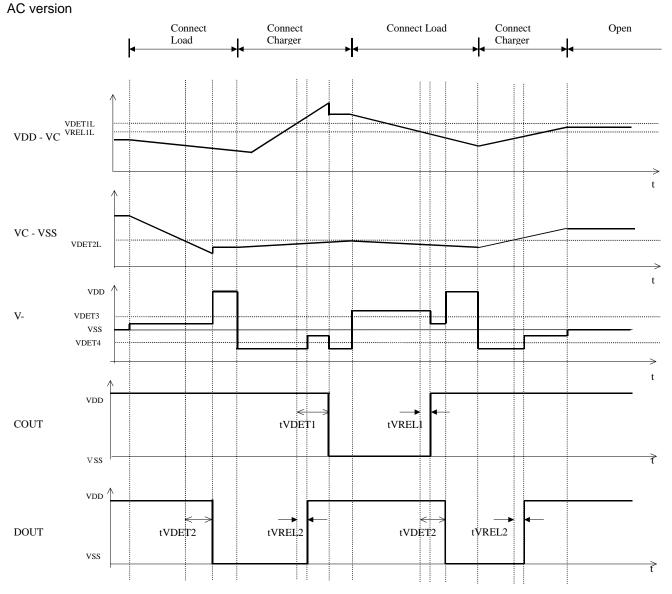


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### AF version

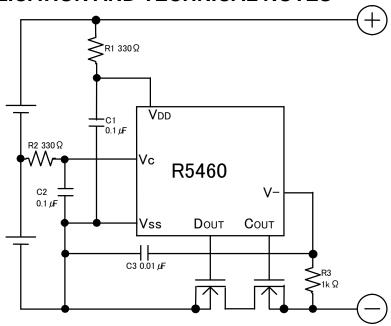


# (3) Operation with unbalanced cells



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# TYPICAL APPLICATION AND TECHNICAL NOTES



### **TECHNICAL NOTES**

R1, R2, C1 and C2 stabilize a supply voltage to the R5460xxxxxx. A recommended R1, R2 value is less than  $1k\Omega$ . A larger value of R1 and R2 makes the detection voltage shift higher because of some conduction current in the R5460x2xxxx.

To stabilize the operation, the value of C1 and C2 should be equal or more than 0.01µF.

R1 and R3 can operate also as parts for current limit circuit against reverse charge or applying a charger with excess charging voltage beyond the absolute maximum rating of the R5460xxxxx, the battery pack. Small value of R1 and R3 may cause over-power consumption rating of power dissipation of the R5460xxxxx. Thus, the total value of 'R1+R3' should be equal or more than  $1k\Omega$ . If a large value R3 is set, after detecting over-discharge, the release by connecting a charger may not be possible. Therefore, recommendation value of R3 is equal or less than  $3k\Omega$ .

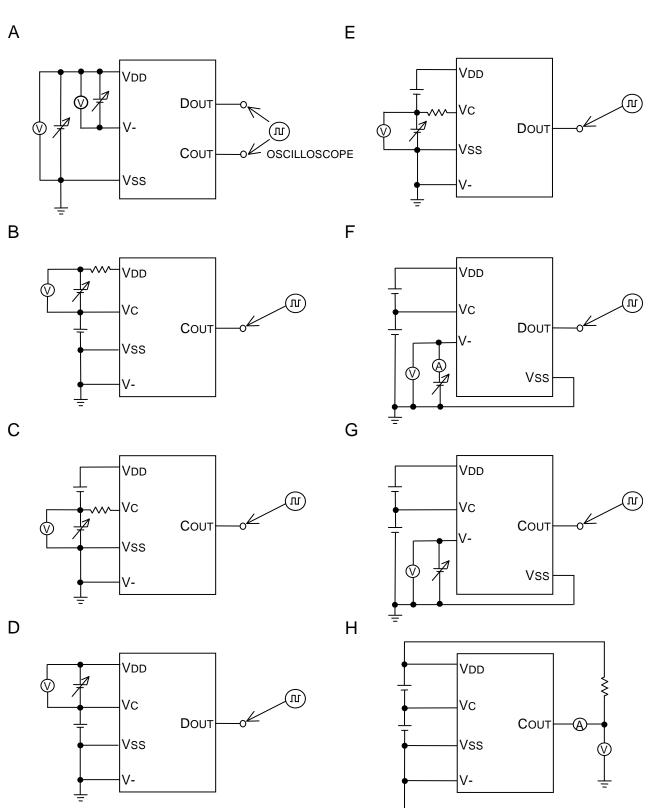
To stabilize the operation of the IC, make sure to mount  $0.01\mu F$  or more capacitor as C3.

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.

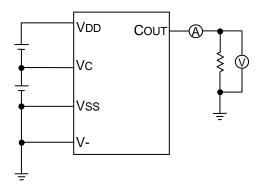
Over-voltage and the over current beyond the absolute maximum rating should not be forced to the protection IC and external components. Although the short protection circuit is built in the IC, if the positive terminal and the negative terminal of the battery pack are short, during the delay time of 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.

We are making our continuous effort to improve the quality and reliability of our products, but semiconductor products are likely to fail with certain probability. In order to prevent any injury to humans or damages to property resulting from such failure, users should be careful enough to incorporate safe measures in design, such as redundancy feature, fire-containment feature and fail-safe feature. We do not assume any liability or responsibility for any loss or damage arising from misuse or inappropriate use of the products.

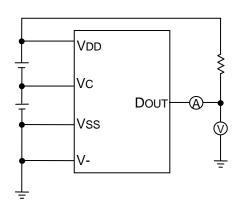
# **TEST CIRCUITS**



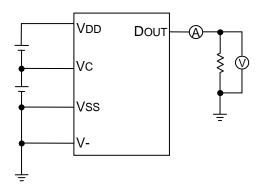
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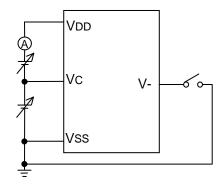
J



K



L



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### Typical Characteristics were obtained with using those above circuits:

Test Circuit A: Part1: Typical characteristics 1)

Test Circuit B: Part1: Typical characteristics 2) 4) 6) 7)

Test Circuit C: Part1: Typical characteristics 3) 5)

Test Circuit D: Part1: Typical characteristics 8) 10) 12) 13)

Test Circuit E: Part1: Typical characteristics 9) 11)

Test Circuit F: Part1: Typical characteristics 14) 15) 16) 17) 18) 19)

Test Circuit G: Part1: Typical characteristics 20) 21) 22) 23)

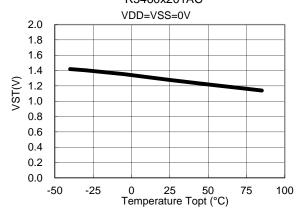
Test Circuit H: Part1: Typical characteristics 24)
Test Circuit I: Part1: Typical characteristics 25)
Test Circuit J: Part1: Typical characteristics 26)
Test Circuit K: Part1: Typical characteristics 27)

Test Circuit L: Part1: Typical characteristics 28) 29) 30)

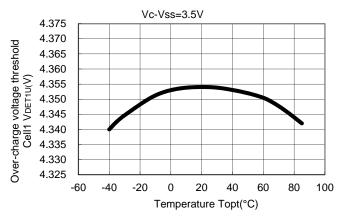
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# **TYPICAL CHARACTERISTICS (Part 1)**

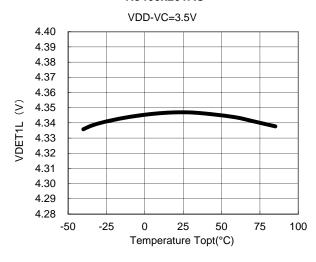
1) Minimum Operating Voltage for 0V Cell Charging R5460x201AC



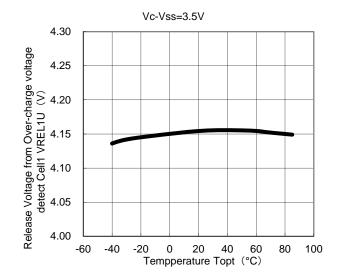
2) Over-charge voltage threshold (Cell1) vs. Temperature R5460x201AC



# 3) Over-Charge Voltage Threshold (Cell2) vs. Temperature R5460x201AC

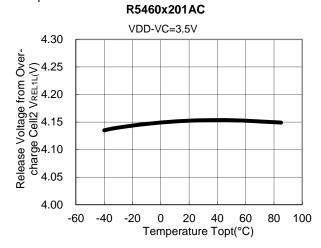


# 4) Release Voltage from Over-charge (Cell1) vs. Temperature R5460x201AC

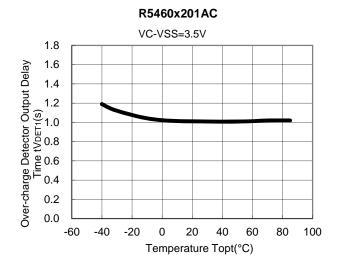


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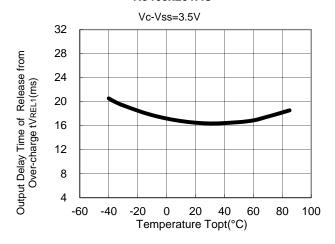
 Release Voltage from Over-charge (Cell2) vs. Temperature



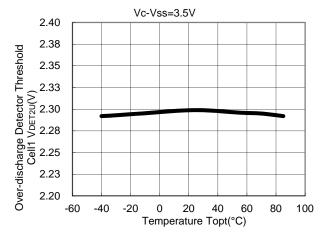
6) Output Delay of Over-charge Detector vs. Temperature



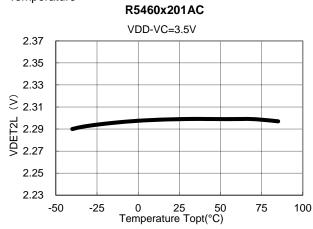
 Output Delay of Release from Over-charge vs. Temperature R5460x201AC



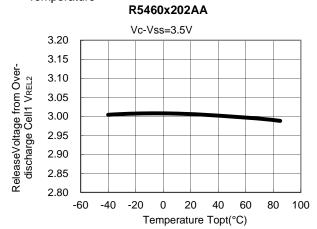
8) Over-discharge Detector Threshold (Cell1) vs. Temperature R5460x201AC



9) Over-discharge Detector Threshold (Cell2) vs. Temperature

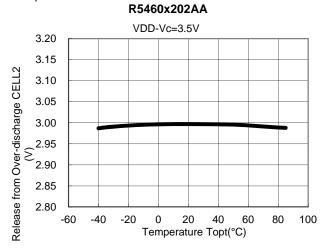


 Release Voltage from Over-discharge (Cell1) vs. Temperature

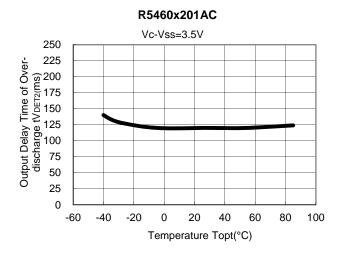


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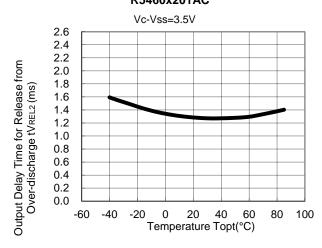
11) Release Voltage from Over-discharge (Cell2) vs. Temperature



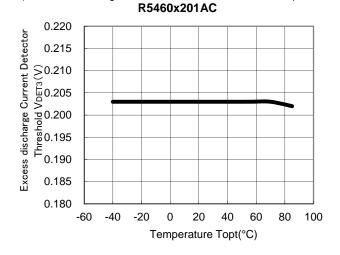
12) Output Delay Time for Over-discharge vs. Temperature



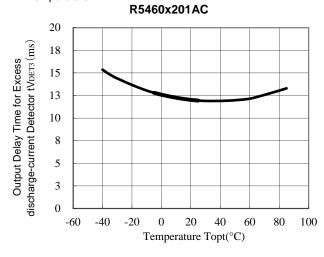
 Output Delay of Release from Over-discharge vs. Temperature R5460x201AC



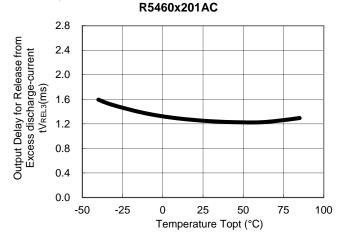
14) Excess discharge Current Detector Threshold vs. Temperature



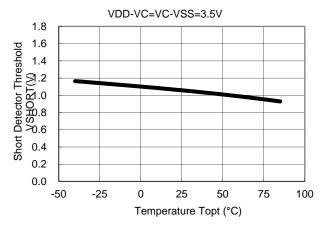
15)Output Delay Time for Excess discharge-current Detector vs. Temperature



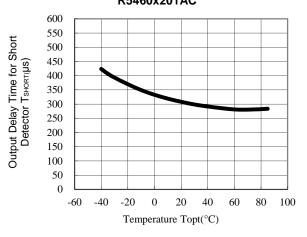
16) Output Delay for Release from Excess discharge-current vs. Temperature



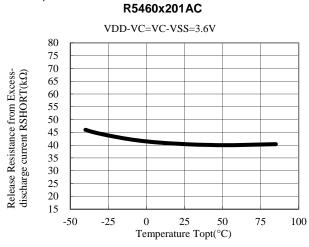
17) Short Detector Voltage Threshold vs. Temperature R5460x201AC



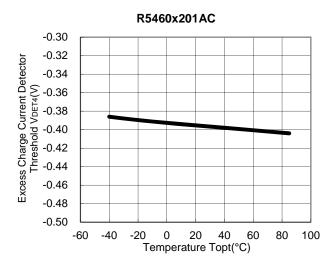
18) Output Delay for Short Detector vs. Temperature R5460x201AC



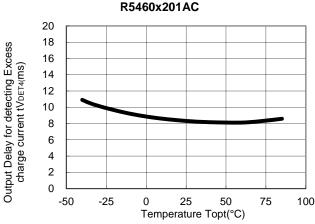
 Release resistance from Excess-discharge current vs. Temperature



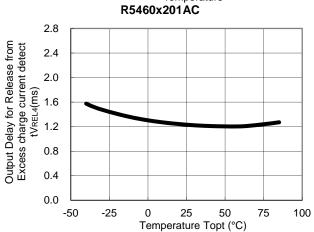
20) Excess-charge current Detector Threshold vs. Temperature



 Output Delay Time of Excess-charge current Detector Threshold vs. Temperature

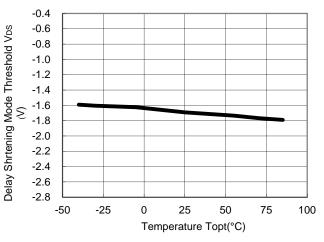


22) Output Delay Time for Release from Excess-charge current vs. Temperature

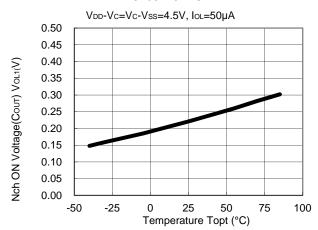


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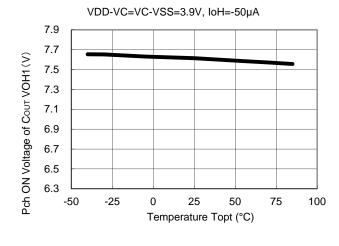
# 23) Delay Shortening Mode Voltage vs. Temperature R5460x201AC



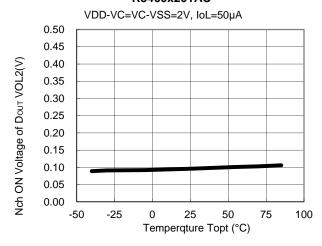
# 24) Nch ON Voltage of Cout vs. Temperature R5460x201AC



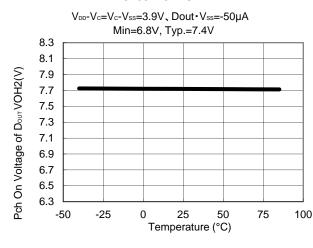
# 25) Pch ON Voltage of COUT vs. Temperature R5460x201AC



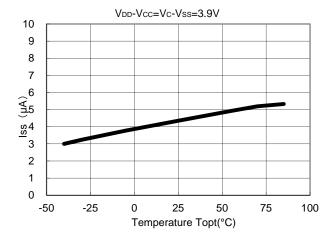
# 26) Nch ON Voltage of DOUT vs. Temperature R5460x201AC



# 27) Pch ON Voltage of DOUT vs. Temperature R5460x201AC

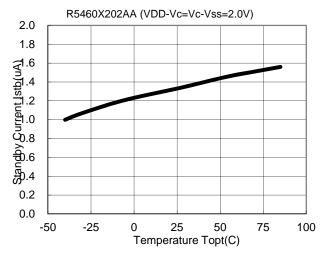


# 28) Supply Current vs. Temperature R5460x201AC

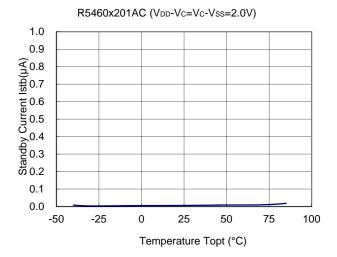


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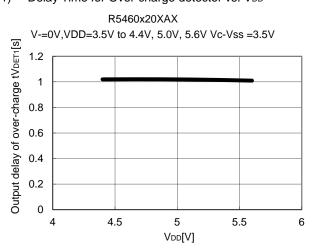
29) Standby Current vs. Temperature (Ver. A.)



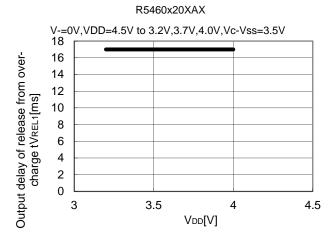
30) Standby Current vs. Temperature (Ver. B.)



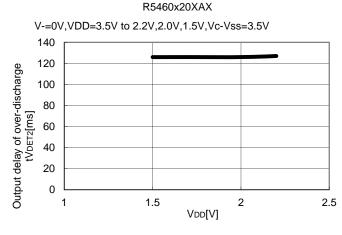
Part 2 Delay Time dependence on VDD 1) Delay Time for Over-charge detector vs. VDD



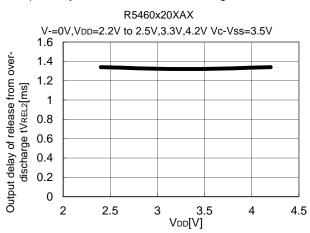
2) Delay Time for Release from Over-charge vs. VDD



3) Output Delay of Over-discharge detector vs. VDD



4) Output Delay for Release from Over-discharge vs. VDD

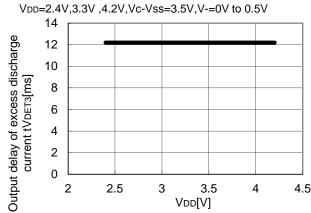


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vs. VDD

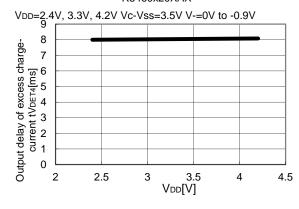
5) Output Delay for Excess Discharge Current vs. V<sub>DD</sub>

#### R5460x20XAX



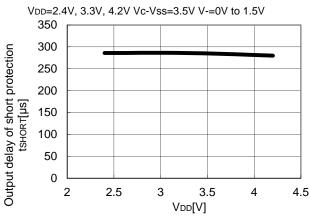
Delay Time for Excess Charge Current Detector

#### R5460x20XAX



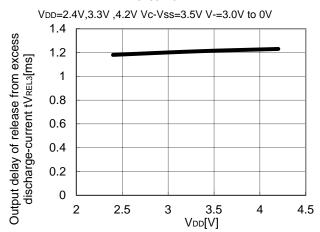
9) Output Delay for Short vs. VDD

### R5460x20XAX



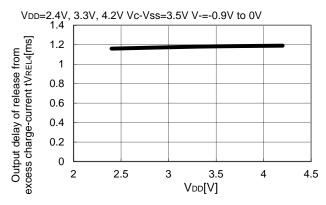
6) Output Delay for Release from Excess Discharge Current Detect vs. V<sub>DD</sub>

#### R5460x20XAX

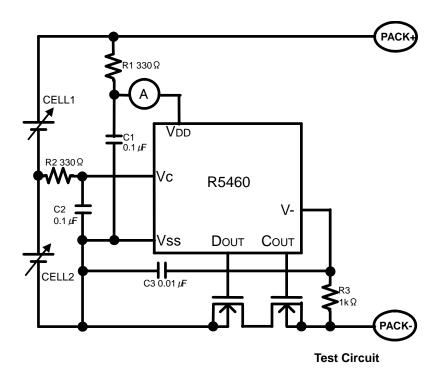


8) Delay Time for release from Excess charge current detect vs. V<sub>DD</sub>

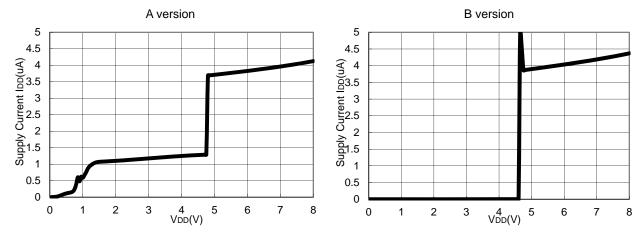
#### R5460x20XAX



Part 3 Supply Current dependence on VDD

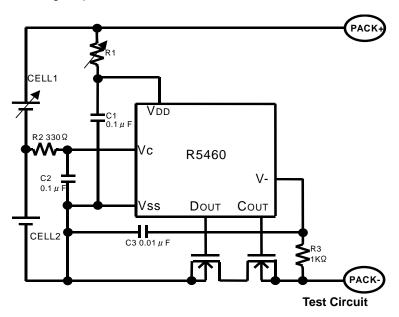


### Supply Current vs. VDD

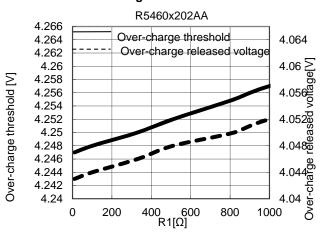


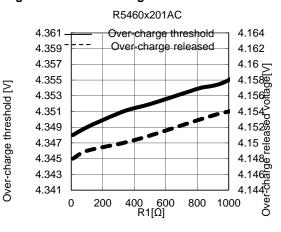
NO.EA-165-160603

Part 4 Over-charge detector, Release voltage from Over-charge, Over-discharge detector, Release voltage from Over-

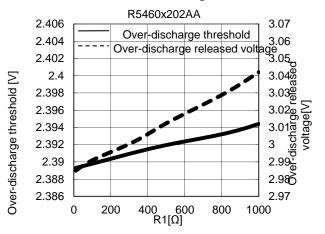


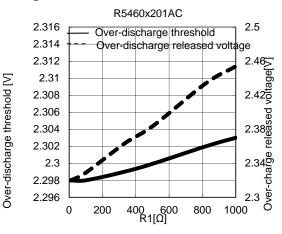
### Over-charge Detector Threshold / Released Voltage from Over-discharge vs. R1





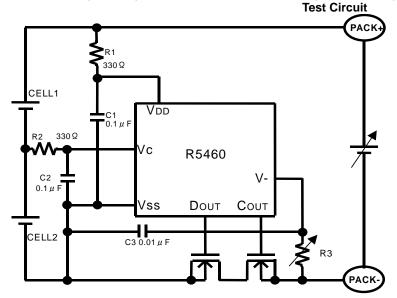
### Over-discharge / Released from Over-charge Threshold vs. R1





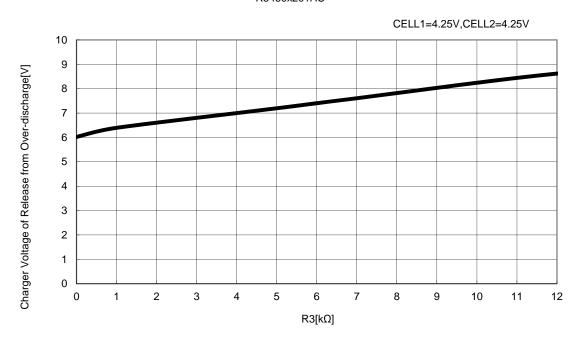
Part 5 Charger Voltage at Released from Over-discharge with a Charger dependence on R2

Test Circuit



Charger Voltage at Release from Over-discharge with a charger vs. R2

R5460x201AC

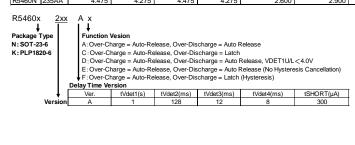


NO.EA-165-160603

### R5460x2xxxx CODE LIST

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Product	Code	CELL1	CELL1	CELL2	CELL2	CELL1	CELL1	CELL2	CELL2	Excess	Excess	Overcharge	Overdischarge
Name	Name	Overcharge	Overcharge	Overcharge	Overcharge	Overdischarge	Overdischarge	Overdischarge	Overdischarge	discharge-current	charge-current	Output	Output
		Detector Threshold	Release Threshold	Detector Threshold	Release Threshold	Detector Threshhold	Release Threshold	Detector Threshold	Release threshhold	Threshold	Threshold	Delay Time	Delay Time
		VDET1U (V)	VREL1U (V)	VDET1L (V)	VREL1L (V)	VDET2U (V)	VREL2U (V)	VDET2L (V)	VREL2L (V)	VDET3 (V)	VDET4 (V)	tVDET1 (s)	tVDET2 (ms)
R5460N	201AC	4.350	4.150	4.350	4.150	2.300	-	2.300	-	0.200	-0.400	1	128
R5460N	202AA	4.250	4.050	4.250	4.050	2.400	3.000	2.400	3.000	0.150	-0.400	1	128
R5460N	203AA	4.350	4.150	4.350	4.150	2.300	3.000	2.300	3.000	0.200	-0.400	1	128
R5460N	204AA	4.350	4.150	4.350	4.150	2.300	3.000	2.300	3.000	0.150	-0.200	1	128
R5460N	205AA	4.250	4.050	4.250	4.050	2.400	3.000	2.400	3.000	0.100	-0.200	1	128
R5460N	206AA	4.290	4.050	4.290	4.050	2.900	3.100	2.900	3.100	0.150	-0.200	1	128
R5460N	207AA	4.350	4.150	4.350	4.150	2.300	3.000	2.300	3.000	0.200	-0.200	1	128
R5460N	207AE	4.350	4.150	4.350	4.150	2.300	3.000	2.300	3.000	0.200	-0.200	1	128
R5460N	207AF	4.350	4.150	4.350	4.150	2.300	3.000	2.300	3.000	0.200	-0.200	1	128
R5460N	208AA	4.250	4.050	4.250	4.050	2.400	3.000	2.400	3.000	0.200	-0.200	1	128
R5460N	208AE	4.250	4.050	4.250	4.050	2.400	3.000	2.400	3.000	0.200	-0.200	1	128
R5460N	208AF	4.250	4.050	4.250	4.050	2.400	3.000	2.400	3.000	0.200	-0.200	1	128
R5460N	209AD	3.650	3.450	3.650	3.450	2.500	3.000	2.500	3.000	0.200	-0.200	1	128
R5460N	210AD	3.650	3.450	3.650	3.450	2.000	2.500	2.000	2.500	0.200	-0.200	1	128
R5460N	211AA	4.250	4.050	4.250	4.050	3.000	3.200	3.000	3.200	0.150	-0.200	1	128
R5460N	212AA	4.290	4.050	4.290	4.050	3.000	3.200	3.000	3.200	0.200	-0.200	1	128
R5460N	212AE	4.290	4.050	4.290	4.050	3.000	3.200	3.000	3.200	0.200	-0.200	1	128
R5460N	212AF	4.290	4.050	4.290	4.050	3.000	3.200	3.000	3.200	0.200	-0.200	1	128
R5460N	213AD	3.900	3.450	3.900	3.450	2.000	2.500	2.000	2.500	0.200	-0.200	1	128
R5460N	214AC	4.250	4.050	4.250	4.050	2.800	-	2.800	-	0.200	-0.200	1	128
R5460N	214AE	4.250	4.050	4.250	4.050	2.800	3.000	2.800	3.000	0.200	-0.200	1	128
R5460N	214AF	4.250	4.050	4.250	4.050	2.800	3.000	2.800	3.000	0.200	-0.200	1	128
R5460N	215AF	4.300	4.100	4.300	4.100	3.200	3.400	3.200	3.400	0.150	-0.200	1	128
R5460N	218AF	4.250	4.050	4.250	4.050	2.800	3.000	2.800	3.000	0.200	-0.100	1	128
R5460N	222AA	4.200	4.100	4.200	4.100	2.700	2.850	2.700	2.850	0.200	-0.200	1	128
R5460N	223AA	4.250	4.100	4.250	4.100	2.500	3.000	2.500	3.000	0.100	-0.100	1	128
R5460N	225AF	4.300	4.100	4.300	4.100	3.000	3.200	3.000	3.200	0.200	-0.150	1	128
R5460N	227AA	4.425	4.000	4.425	4.000	2.800	3.000	2.800	3.000	0.150	-0.150	1	128
R5460N	229AD	3.650	3.300	3.650	3.300	2.000	2.500	2.000	2.500	0.200	-0.200	1	128
R5460N	230AA	4.375	4.175	4.375	4.175	2.500	2.700	2.500	2.700	0.100	-0.100	1	128
R5460N	233AF	4.100	3.950	4.100	3.950	2.800	3.000	2.800	3.000	0.200	-0.200	1	128
R5460N	235AA	4.475	4.275	4.475	4.275	2.600	2.900	2.600	2.900	0.200	-0.200	1	128





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