PRODUCT SPECIFICATIONS

R5441Z Series

CONTENTS

[1] Outline

The R5441Z is one-cell Li-ion / Li-polymer rechargeable battery protection IC features overcharge, discharge, overcurrent, and temperature protections. The R5441Z can detect over-charge/discharge of Li+ one-cell and excess load current, further include a short circuit protector for preventing large external short circuit current and the excess charge-current. It's possible to detect the temperature by connecting a thermistor. The R5441Z consists of four voltage detectors, two temperature detectors, a reference unit, a delay circuit, a short circuit detector, two oscillators, two counters, and a logic circuit.

When the R5441Z detects over-charge or excess charge current, the output of COUT pin switches to “L” level, that is, the charger’s negative pin level after the internal fixed delay time. When the R5441Z detects over-discharge or excess discharge current, the output of DOUT pin switches to “L” level after the internal fixed delay time.

After detecting over-charge or excess charge current, the R5441Z can be reset and the output of COUT becomes “H” when a charger is disconnected from the battery pack, and the cell voltage becomes lower than over-charge detector threshold.

However, depending on the characteristics of external components such as MOSFETs, release conditions may be not enough just removing a charger from the battery pack. In that case, a kind of load must be set to release the over-charge detect.

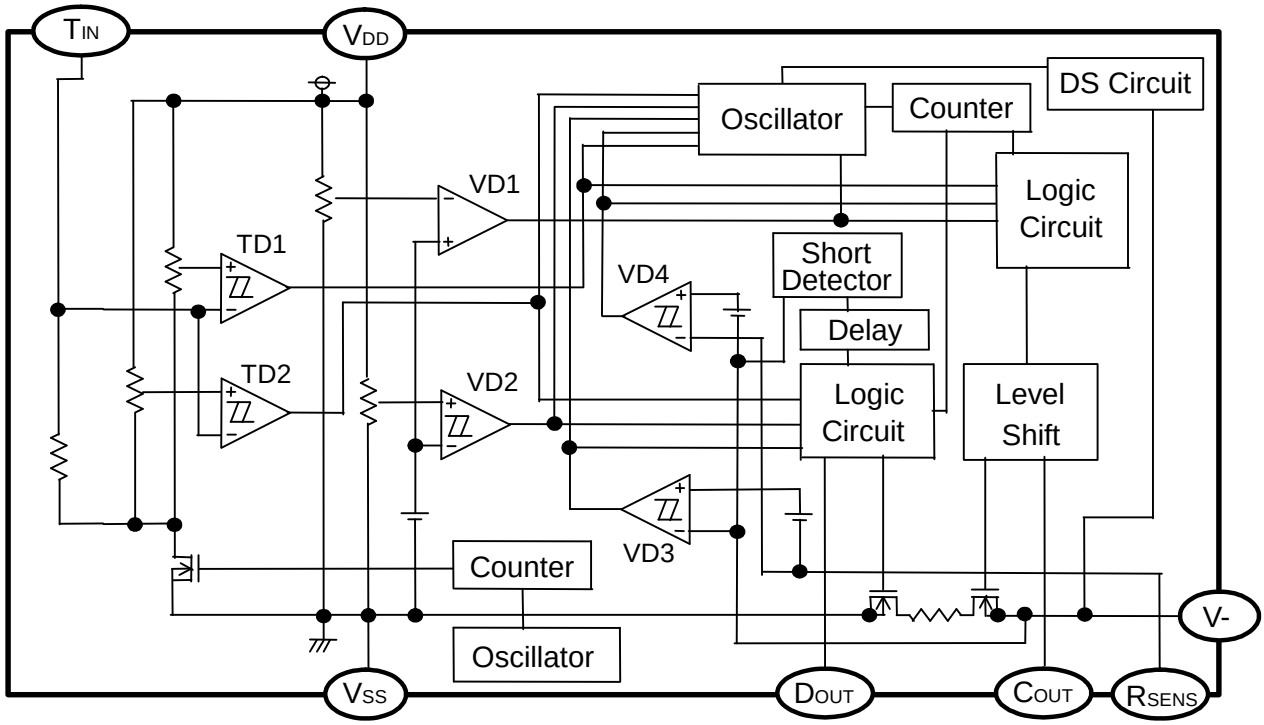
If a charger is continuously connected to the battery pack, even if the cell voltage becomes lower than over-charge detector threshold, over-charge state is not released.

After detecting over-discharge voltage, connect a charger to the battery pack, and when the battery supply voltage becomes higher than over-discharge release threshold, the R5441Z is released and the voltage of DOUT pin becomes “H”. If the battery is discharged lower than maximum voltage for inhibition of charger, recharge current is not acceptable. Once after detecting excess discharge-current or short circuit, the R5441Z is released and DOUT level becomes “H” with connecting a battery pack from a charger. After detecting over-discharge, supply current is kept extremely low by halting internal circuits' operation.

When high temperature is detected, COUT and DOUT outputs will be the "L" level.

When the output of COUT is "H", by setting the V- pin at equal or lower than the delay shortening mode voltage (Typ. -2.0V), the output delay can be shortened. Especially, the delay time of over charge detector can be reduced into approximately 1/110. Thus, testing time of protector circuit board can be reduced. Output type of COUT and DOUT is CMOS.

[2] Block Diagram



[3] Pin Description

Pin No.	Symbol	Pin Description
A1	V-	Charger negative input pin
B1	VDD	Power supply pin, The substrate level of the IC
C1	NC	No connection
D1	VSS	Ground pin, The ground pin of the IC
A2	COUT	Output pin of over-charge detection, CMOS output
B2	RSENS	Over-current detector input pin
C2	TIN	Thermistor input pin for temperature detection
D2	DOUT	Output pin of over-discharge detection, CMOS output

[4] Absolute Maximum Ratings

Ta=25°C, Vss=0V

Item	Symbol	Ratings	Unit
Supply Voltage	VDD	-0.3 to 12	V
Input Voltage			
V- pin Voltage	V-	VDD-30 to VDD+0.3	V
RSENS pin Voltage	VRSENS	VDD-30 to VDD+0.3	V
TIN pin Voltage	VTIN	VSS-0.3 to VDD+0.3	V
Output Voltage			
COUT pin Voltage	VCOUT	VDD-30 to VDD+0.3	V
DOUT pin Voltage	VDOUT	Vss-0.3 to VDD+0.3	V
Power Dissipation	PD	150	mW
Operating Temperature	Ta	-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.

[5] Electrical Characteristics

●R5441ZxxxxV

Unless otherwise provided, Ta=25°C

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit	Note1
Operating Input Voltage	$V_{DD}1$	V_{DD}- Vss	1.5		5.0	V	A
Minimum Operating Voltage for 0V Charging	Vst	Voltage Defined as V_{DD}-V-, V_{DD}-Vss=0V			1.8	V	A
Over-charge Threshold Voltage	$V_{DET}1$	R1=330Ω,Ta=0℃～+50℃ * Note2	$V_{DET}1$ -0.010	$V_{DET}1$	$V_{DET}1$ +0.010	V	B
Output Delay of Over-charge	$tV_{DET}1$	V_{DD}=3.6V to 4.6V	0.80	1.00	1.20	s	B
Release Delay for VD1	$tV_{REL}1$	V_{DD}=4V, V-=0V to 1V	12.0	16.0	20.0	ms	C
Over-discharge Threshold	$V_{DET}2$	Detect falling edge of supply voltage	$V_{DET}2$ × 0.98	$V_{DET}2$	$V_{DET}2$ × 1.02	V	D
Output Delay of Over-discharge	$tV_{DET}2$	V_{DD}=3.6V to 2.0V	$tV_{DET}2$ × 0.80	$tV_{DET}2$	$tV_{DET}2$ × 1.20	ms	D
Release Delay for VD2	$tV_{REL}2$	V_{DD}=3.6V, V-=3.6V to 0V	0.85	1.10	1.35	ms	E
Excess discharge-current Threshold (0.015V to 0.030V)	$V_{DET}3$	Detect rising edge of 'V-' pin voltage	$V_{DET}3$ -0.003	$V_{DET}3$	$V_{DET}3$ +0.003	V	F
Excess discharge-current Threshold (0.031V to 0.050V)	$V_{DET}3$	Detect rising edge of 'V-' pin voltage	$V_{DET}3$ ×0.900	$V_{DET}3$	$V_{DET}3$ ×1.100	V	F
Excess discharge-current Threshold (0.051V to 0.150V)	$V_{DET}3$	Detect rising edge of 'V-' pin voltage	$V_{DET}3$ -0.005	$V_{DET}3$	$V_{DET}3$ +0.005	V	F
Output delay of excess discharge-current	$tV_{DET}3$	V_{DD}=3.6V, V-=0V to $V_{DET}3$+0.010 V_{RSENS}=0V	$tV_{DET}3$ ×0.80	$tV_{DET}3$	$tV_{DET}3$ ×1.20	ms	F
Output delay of release from excess discharge-current	$tV_{REL}3$	V_{DD}=3.6V, V- = 3V to -1V V_{RSENS} = 0V	0.85	1.10	1.35	ms	F
Short Protection Voltage	Vshort	Detect rising edge of ' V- ' pin voltage	Vshort -0.005	Vshort	Vshort +0.005	V	F
Delay Time for Short Protection	tshort	V_{DD}=3.6V, V-=0V to Vshort+0.010 V_{RSENS}=0V	210	280	350	μs	F
Reset Resistance for Excess Current Protection	Rshort	V_{DD}=3.6V,V- =1.0V V_{RSENS}=0V	20	45	70	kΩ	F
Excess charge-current Threshold (-0.020V to -0.015V)	$V_{DET}4$	Detect falling edge of ' V- ' pin voltage	$V_{DET}4$ -0.004	$V_{DET}4$	$V_{DET}4$ +0.004	V	F
Excess charge-current threshold (-0.040V to -0.021V)	$V_{DET}4$	Detect falling edge of ' V- ' pin voltage	$V_{DET}4$ ×0.800	$V_{DET}4$	$V_{DET}4$ ×1.200	V	F
Excess charge-current threshold (-0.150V to -0.040V)	$V_{DET}4$	Detect falling edge of ' V- ' pin voltage	$V_{DET}4$ -0.008	$V_{DET}4$	$V_{DET}4$ +0.008	V	F
Output delay of excess charge-current	$tV_{DET}4$	V_{DD}=3.6V, V- = 0V to -1V V_{RSENS} = 0V	6	8	10	ms	F
Output delay of release from excess charge-current	$tV_{REL}4$	V_{DD}=3.6V, V- = -1V to 0.3V V_{RSENS} = 0V	0.85	1.10	1.35	ms	F
Delay Time Shortening Mode Voltage	V_{DS}	V_{DD}=3.6V	-2.6	-2.0	-1.4	V	G
Nch ON-Voltage of C_{OUT}	$V_{OL}1$	Iol=50μA, V_{DD}=4.55V		0.4	0.5	V	H
Pch ON-Voltage of C_{OUT}	$V_{OH}1$	Ioh=-50μA, V_{DD}=3.9V	3.4	3.7		V	I
Nch ON-Voltage of D_{OUT}	$V_{OL}2$	Iol=50μA, V_{DD}=2.0V		0.2	0.5	V	J
Pch ON-Voltage of D_{OUT}	$V_{OH}2$	Ioh=-50μA, V_{DD}=3.9V	3.4	3.7		V	K
Supply Current	I_{DD}	V_{DD}=3.9V, V- = V_{RSENS} = 0V		2.5	6.0	μA	L
Standby Current	Istandby	V_{DD}=2.0V			0.04	μA	L

●: 'Note1' Indicates test circuits shown in page8

●: 'Note2' Considering of variation in process parameters, we compensate for this characteristic related to temperature by laser-trim, however, this specification is guaranteed by design, not mass production tested.

Unless otherwise provided, Ta=25°C

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit	Note1
Thermal detector1 threshold	T_{DET1}	NTC performance Resistance = 100kΩ±1%(25℃) B-Constant = 4250K±1%	T_{DET1} -3.0	T_{DET1}	T_{DET1} +3.0	℃	P
Thermal release1 threshold	T_{REL1}	NTC performance Resistance = 100kΩ±1%(25℃) B-Constant = 4250K±1%	T_{REL1} -3.0	T_{REL1}	T_{REL1} +3.0	℃	P
Thermal detector2 threshold	T_{DET2}	NTC performance Resistance = 100kΩ±1%(25℃) B-Constant = 4250K±1%	T_{DET2} -3.0	T_{DET2}	T_{DET2} +3.0	℃	Q
Thermal release2 threshold	T_{REL2}	NTC performance Resistance = 100kΩ±1%(25℃) B-Constant = 4250K±1%	T_{REL2} -3.0	T_{REL2}	T_{REL2} +3.0	℃	Q
Internal resistance for Temperature sense	RTIN		59	96	133	kΩ	R
Temperature sense time	TTS	V_{DD}=3.6V	8	10	12	ms	R
Output Delay of Thermal detection	tT_{DET}	V_{DD}=3.6V	tT_{DET} ×0.80	tT_{DET}	tT_{DET} ×1.20	ms	P,Q
Release Delay for T_{DET}	tT_{REL}	V_{DD}=3.6V	102	128	154	ms	P,Q
Temperature Non-sense time	TTNS	V_{DD}=3.6V	320	400	480	ms	R

●: 'Note1' Indicates test circuits shown in page8

●R5441ZxxxxW Unless otherwise provided, Ta=25°C

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit	Note1
Operating Input Voltage	$V_{DD}1$	V_{DD}- Vss	1.5		5.0	V	A
Maximum Operating Voltage for Inhibition of Charger	Vnochg	Voltage Defined as V_{DD}-Vss, VDD-V-=4V	1.0	1.25	1.5	V	A
Over-charge Threshold Voltage	$V_{DET}1$	R1=330Ω,Ta=0℃～+50℃ * Note2	$V_{DET}1$ -0.010	$V_{DET}1$	$V_{DET}1$ +0.010	V	B
Output Delay of Over-charge	$tV_{DET}1$	V_{DD}=3.6V to 4.6V	0.80	1.00	1.20	s	B
Release Delay for VD1	$tV_{REL}1$	V_{DD}=4V, V-=0V to 1V	12.0	16.0	20.0	ms	C
Over-discharge Threshold	$V_{DET}2$	Detect falling edge of supply voltage	$V_{DET}2$ × 0.98	$V_{DET}2$	$V_{DET}2$ × 1.02	V	D
Output Delay of Over-discharge	$tV_{DET}2$	V_{DD}=3.6V to 2.0V	$tV_{DET}2$ × 0.80	$tV_{DET}2$	$tV_{DET}2$ × 1.20	ms	D
Release Delay for VD2	$tV_{REL}2$	V_{DD}=3.6V, V-=3.6V to 0V	0.85	1.10	1.35	ms	E
Excess discharge-current Threshold (0.015V to 0.030V)	$V_{DET}3$	Detect rising edge of 'V-' pin voltage	$V_{DET}3$ -0.003	$V_{DET}3$	$V_{DET}3$ +0.003	V	F
Excess discharge-current Threshold (0.031V to 0.050V)	$V_{DET}3$	Detect rising edge of 'V-' pin voltage	$V_{DET}3$ ×0.900	$V_{DET}3$	$V_{DET}3$ ×1.100	V	F
Excess discharge-current Threshold (0.051V to 0.150V)	$V_{DET}3$	Detect rising edge of 'V-' pin voltage	$V_{DET}3$ -0.005	$V_{DET}3$	$V_{DET}3$ +0.005	V	F
Output delay of excess discharge-current	$tV_{DET}3$	V_{DD}=3.6V, V-=0V to $V_{DET}3$+0.010 V_{RSENS}=0V	$tV_{DET}3$ ×0.80	$tV_{DET}3$	$tV_{DET}3$ ×1.20	ms	F
Output delay of release from excess discharge-current	$tV_{REL}3$	V_{DD}=3.6V, V- = 3V to -1V V_{RSENS} = 0V	0.85	1.10	1.35	ms	F
Short Protection Voltage	Vshort	Detect rising edge of ' V- ' pin voltage	Vshort -0.005	Vshort	Vshort +0.005	V	F
Delay Time for Short Protection	tshort	V_{DD}=3.6V, V-=0V to Vshort+0.010 V_{RSENS}=0V	210	280	350	μs	F
Reset Resistance for Excess Current Protection	Rshort	V_{DD}=3.6V,V- =1.0V V_{RSENS}=0V	20	45	70	kΩ	F
Excess charge-current Threshold (-0.020V to -0.015V)	$V_{DET}4$	Detect falling edge of ' V- ' pin voltage	$V_{DET}4$ -0.004	$V_{DET}4$	$V_{DET}4$ +0.004	V	F
Excess charge-current threshold (-0.040V to -0.021V)	$V_{DET}4$	Detect falling edge of ' V- ' pin voltage	$V_{DET}4$ ×0.800	$V_{DET}4$	$V_{DET}4$ ×1.200	V	F
Excess charge-current threshold (-0.150V to -0.040V)	$V_{DET}4$	Detect falling edge of ' V- ' pin voltage	$V_{DET}4$ -0.008	$V_{DET}4$	$V_{DET}4$ +0.008	V	F
Output delay of excess charge-current	$tV_{DET}4$	V_{DD}=3.6V, V- = 0V to -1V V_{RSENS} = 0V	6	8	10	ms	F
Output delay of release from excess charge-current	$tV_{REL}4$	V_{DD}=3.6V, V- = -1V to 0.3V V_{RSENS} = 0V	0.85	1.10	1.35	ms	F
Delay Time Shortening Mode Voltage	V_{DS}	V_{DD}=3.6V	-2.6	-2.0	-1.4	V	G
Nch ON-Voltage of C_{OUT}	$V_{OL}1$	Iol=50μA, V_{DD}=4.55V		0.4	0.5	V	H
Pch ON-Voltage of C_{OUT}	$V_{OH}1$	Ioh=-50μA, V_{DD}=3.9V	3.4	3.7		V	I
Nch ON-Voltage of D_{OUT}	$V_{OL}2$	Iol=50μA, V_{DD}=2.0V		0.2	0.5	V	J
Pch ON-Voltage of D_{OUT}	$V_{OH}2$	Ioh=-50μA, V_{DD}=3.9V	3.4	3.7		V	K
Supply Current	IDD	V_{DD}=3.9V, V- = V_{RSENS} = 0V		2.5	6.0	μA	L
Standby Current	Istandby	V_{DD}=2.0V			0.04	μA	L

●: 'Note1' Indicates test circuits shown in page8

●: 'Note2' Considering of variation in process parameters, we compensate for this characteristic related to temperature by laser-trim, however, this specification is guaranteed by design, not mass production tested.

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Item	Symbol	Conditions	Min.	Typ.	Max.	Unit	Note1
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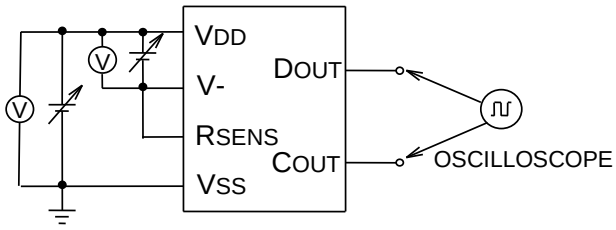
Thermal release1 threshold	T_{REL1}	NTC performance Resistance = 100kΩ±1%(25℃) B-Constant = 4250K±1%	T_{REL1} -3.0	T_{REL1}	T_{REL1} +3.0	℃	P
Thermal detector2 threshold	T_{DET2}	NTC performance Resistance = 100kΩ±1%(25℃) B-Constant = 4250K±1%	T_{DET2} -3.0	T_{DET2}	T_{DET2} +3.0	℃	Q
Thermal release2 threshold	T_{REL2}	NTC performance Resistance = 100kΩ±1%(25℃) B-Constant = 4250K±1%	T_{REL2} -3.0	T_{REL2}	T_{REL2} +3.0	℃	Q
Internal resistance for Temperature sense	RTIN		59	96	133	kΩ	R
Temperature sense time	TTS	V_{DD}=3.6V	8	10	12	ms	R
Output Delay of Thermal detection	tT_{DET}	V_{DD}=3.6V	tT_{DET} ×0.80	tT_{DET}	tT_{DET} ×1.20	ms	P,Q
Release Delay for T_{DET}	tT_{REL}	V_{DD}=3.6V	102	128	154	ms	P,Q
Temperature Non-sense time	TTNS	V_{DD}=3.6V	320	400	480	ms	R

●: 'Note1' Indicates test circuits shown in page8

[6] Test Circuits

A



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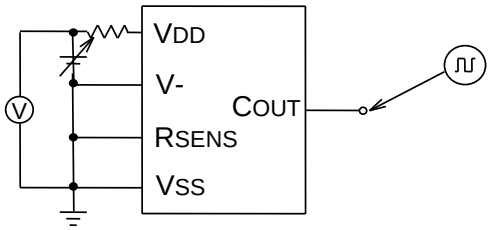

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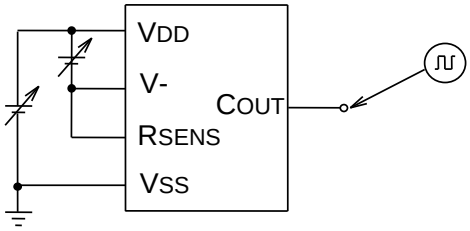

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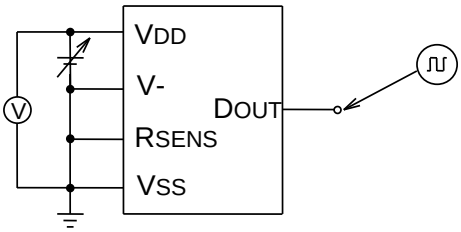

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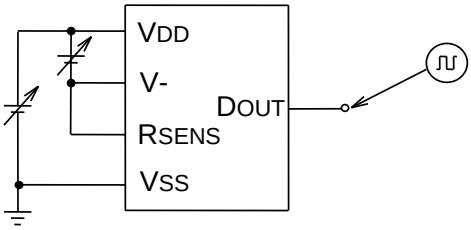

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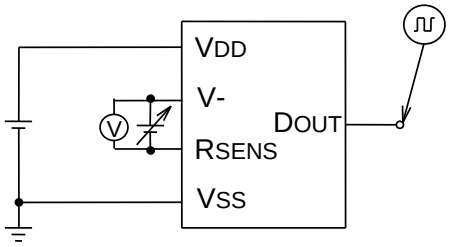

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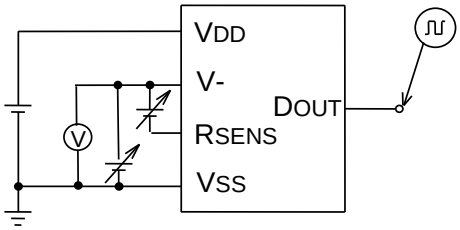

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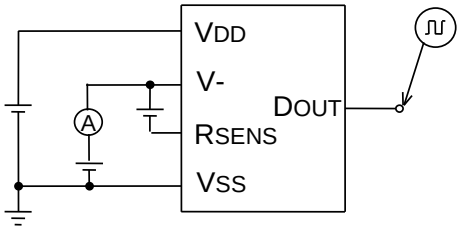

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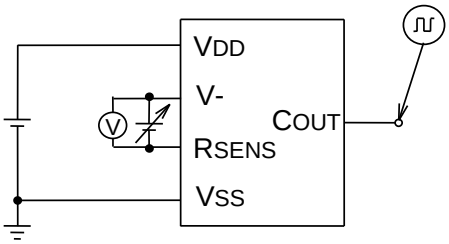

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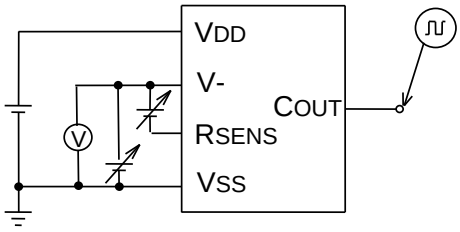

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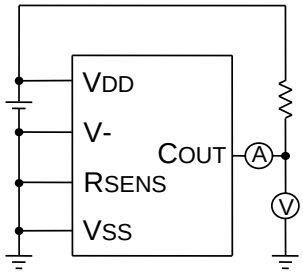
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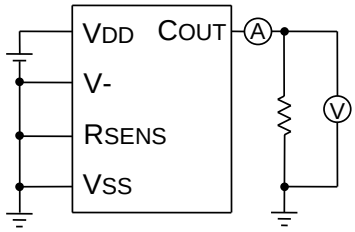
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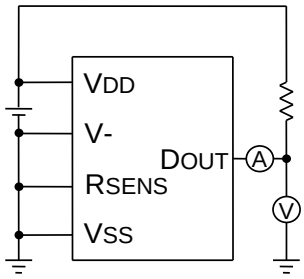
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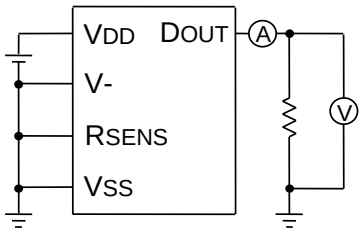
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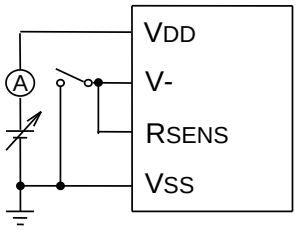
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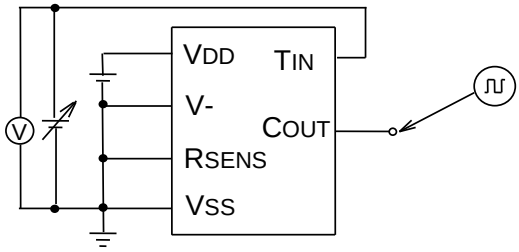
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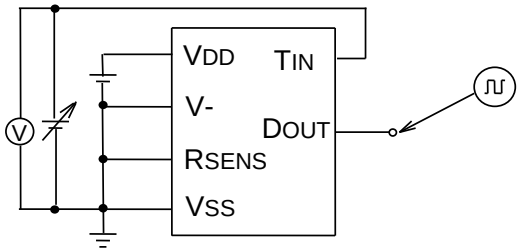
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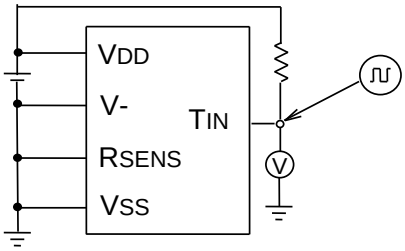
V

R


VDD
V-
TIN
RSENS
VSS
V

[7] Operation

● VD1 / Over-charge Detector

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

After detecting over-charge, when the voltage of V_{DD} pin is less than over-charge detector threshold, and after disconnecting a charger, VD1 is released. However, depending on the characteristics of external components such as MOSFETs, release conditions may be not enough and a kind of load must be set to release the over-charge. Then, the output level of COUT becomes “H” and by turning on the external Nch-MOSFET, the battery charger is ready to work again. In other words, once detecting over-charge, even if the cell voltage would become lower than V_{DET1}, if a charger were being set, recharge is impossible. Therefore, there is no hysteresis for VD1. To judge whether or not load is connected, the excess-discharge current detector is used. In other words, by connecting some load, V- pin voltage becomes equal or more than the excess-discharge current detector threshold, and reset the over-charge detecting state.

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

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

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

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

• VD2/Over-discharge Detector

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

To reset the VD2 with the D_{OUT} pin level being “H” again after detecting over-discharge, if V_{DD} voltage is equal or less than over-charge detector threshold, a charge current flows through a parasitic diode of the external Nch MOSFET. After that, when V_{DD} voltage is more than over-discharge threshold, D_{OUT} pin becomes "H", and by tuning on the external Nch MOSFET, discharge is possible. In the case that a charger is connected to the battery pack, and V_{DD} level is more than over-discharge detector threshold, the output level of D_{OUT} becomes “H” immediately.

A charge operation when a cell voltage equals to zero is different according to the function version.

R5441xxxxV: When a cell voltage is equal to 0V, connecting a charger to the battery pack makes C_{OUT} pin become "H" and the system is allowable for charge while the voltage of the charger is more than the maximum limit of the minimum operating voltage (Vst) for 0V charge.

R5441xxxxW: When the V_{DD} pin voltage is equal or less than the maximum voltage for inhibition of charger (Vnochg), even if a charger is connected to the battery pack, C_{OUT} pin is stacked with "L" and the system is not allowable for charge.

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

After detecting over-discharge by VD2, supply current would decrease, (V_{DD}=2.0V, Max. 0.04μA.) because all circuits are halted and being standby.

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

• VD3/ Excess Discharge Current Detector, Short Circuit Protector

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

An output delay time for the excess discharge current detector is internally fixed. Although the voltage between V- pin and RSENS pin becomes equal or more than the excess discharge current threshold voltage and less than short detector threshold, if it becomes less than the excess current detector threshold voltage within the output delay time, the excess current detector does not work. Output delay time for release from excess discharge current is also set internally.

The V- pin has a built-in pull down resistor, Typ. 45kΩ connected to the Vss pin.
After an excess discharge current or short circuit protection is detected, by removing a cause of excess current or external short circuit, the voltage level of V- is pulled down through the resistor for release from excess current to the Vss level. Then, when the voltage level between V- pin and VSS pin becomes equal or less than the excess current threshold voltage, both protection circuits are released automatically. Resistor for release from excess discharge current is active when excess discharge current or short circuit is detected. While charge and discharge are acceptable for the battery pack, or normal mode, the resistor is inactive.

Even if the excess discharge current detection delay time is set longer than the over-discharge detection delay time, the R5441 goes into the excess discharge current state if the VDD voltage drops below the over-discharge detection threshold when the excess discharge current is detected. In this case the R5441 can be automatically released from the excess discharge current state by disconnecting a load from the battery pack.

• VD4/ Excess charge-current detector

While charge and discharge are acceptable with the battery pack, VD4 monitors the voltage level between V- pin and RSENS pin. For example, if the voltage level between V- pin and RSENS pin may become equal or more than the excess charge current threshold, the excess charge current detector works and the output level of COUT becomes “L”, and by turning off an external Nch MOSFET, VD4 protects against flowing extremely large current into the circuit.

Output delay of the excess charge current is internally fixed. Even the voltage level of between V- pin and RSENS pin becomes equal or lower than the excess charge-current detector threshold, if the voltage is higher than the VD4 threshold within the delay time, the excess charge-current state is not detected. Output delay time for release from excess charge current is also set internally.

VD4 can be released with disconnecting a charger.

• DS (Delay Shortening) function

Output delay time of over-charge and over-discharge can be shorter than those setting values by forcing equal or lower than the test shortening mode voltage (Typ. -2.0V) to V- pin.

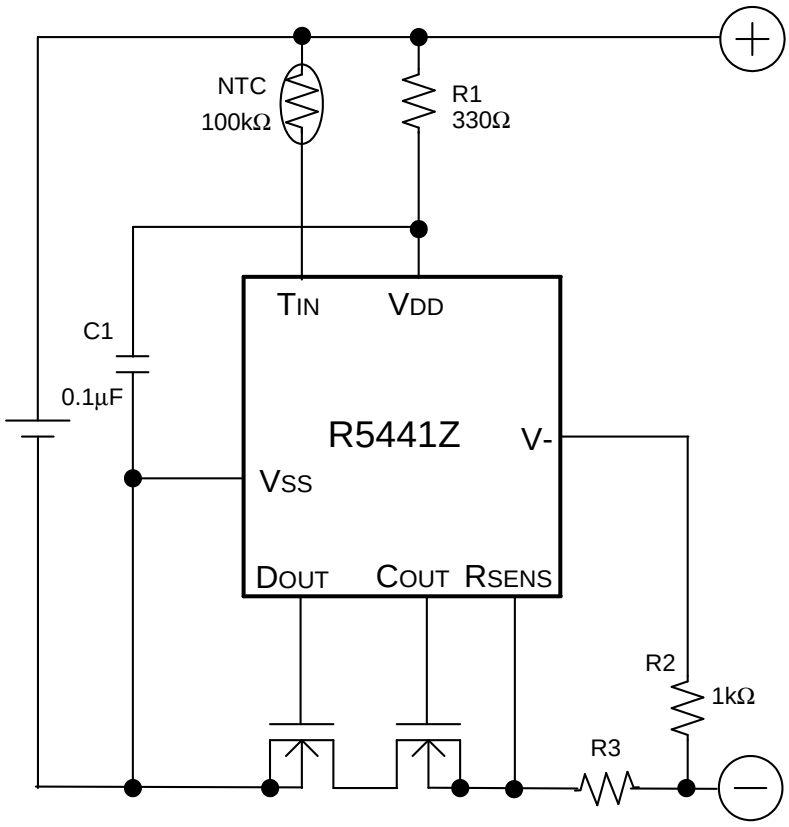
• TD/ Thermal detector

The R5441Z converts the temperature, which is detected by a built-in resistor and a thermistor connected with TIN pin, to the voltage and monitors it. The thermistor works only a period of 10ms every a cycle of 410ms to save the supply current.

COUT pin becomes “Low” when the temperature higher than T_{DET1} is detected and sustained over t_{TDET}, and charging stops by turning off the external Nch. MOSFET. Likewise, DOUT pin becomes “Low” when the temperature higher than T_{DET2} is detected and sustained over t_{TDET}, and discharging stops by turning off it.

If the R5441Z, as discrete device, detects an abnormal temperature, COUT or DOUT pin becomes “High” when the temperature decreases lower than T_{REL1} or T_{REL2}.

[8] Technical Notes



*R1 and C1 stabilize a supply voltage to the R5441. A recommended R1 value is less than 1kΩ. A large value of R1 makes detection voltage shift higher because of conduction current flowed in the R5441.
Further, to stabilize the operation of R5441, use the C1 with the value of 0.01µF or more.

R1 and R2 can operate also as parts for current limit circuit against reverse charge or applying a charger with excess charging voltage to the R5441, battery pack. While small value of R1 and R2 may cause over power dissipation rating of the R5441, therefore a total of “R1+R2” should be 1kΩ or more. Besides, if large value of R2 is set, release from over-discharge by connecting a charger might not be possible. Recommended R2 value is equal or less than 10kΩ.

R3 is a resistor for sensing an excess current. If the resistance value is too large, power loss becomes also large. By the excess current, if the R3 is not appropriate, the power loss may be beyond the power dissipation of R3. Choose an appropriate R3 according to the cell specification.

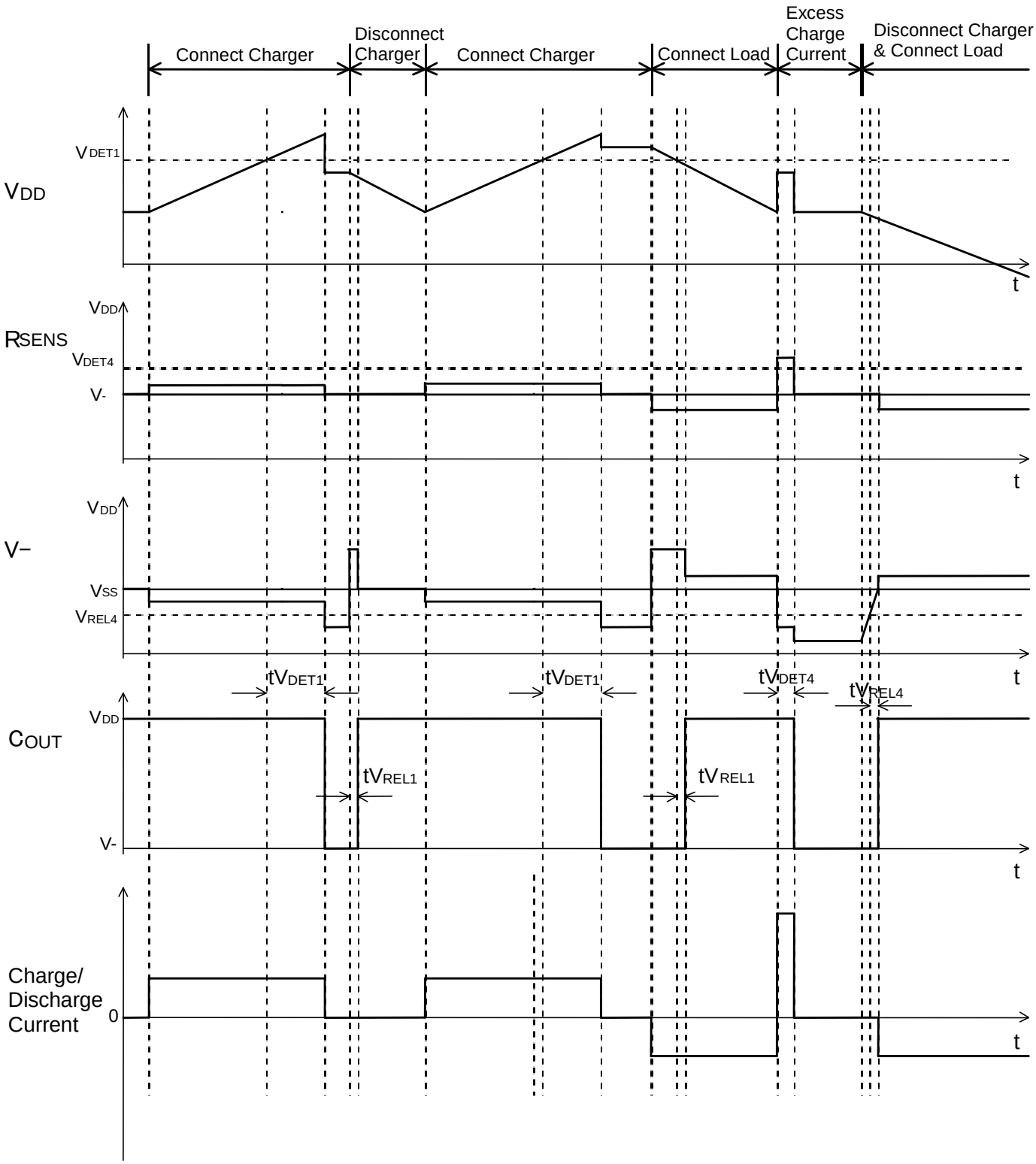
The R5441Z requires a NTC thermistor having a reference resistance value of 100kΩ at 25°C and B-constant of 4250K.

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.

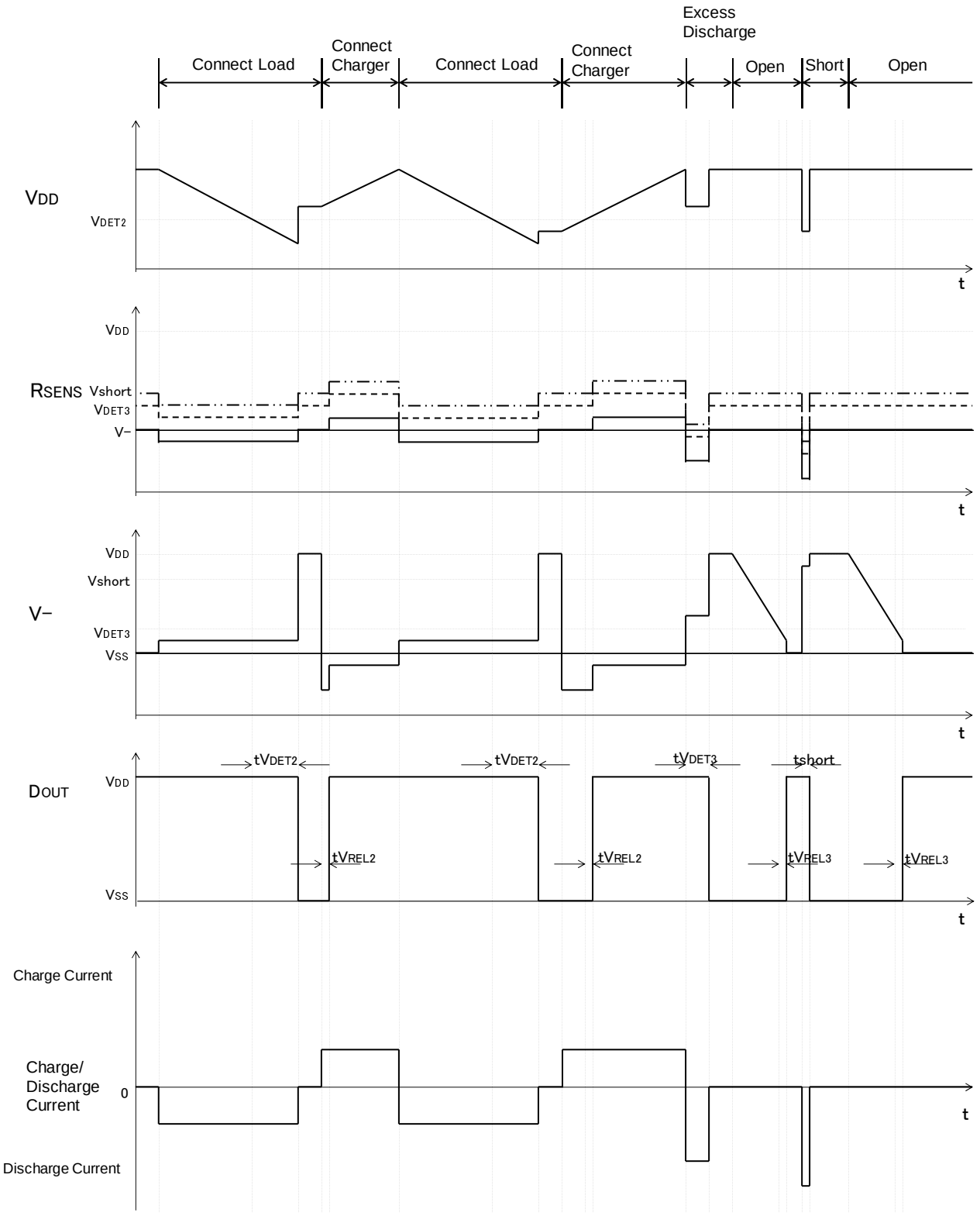
Although the short protection circuit is built in the IC, if the positive terminal and the negative terminal of the battery pack are short, during the delay time of short limit detector, large current flows through the FET. Select an appropriate FET with large enough current capacity to prevent the IC 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 prevent any injury to persons or damages to property resulting from such failure, customers should be careful enough to incorporate safety measures in their 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.

[9] Timing Diagrams

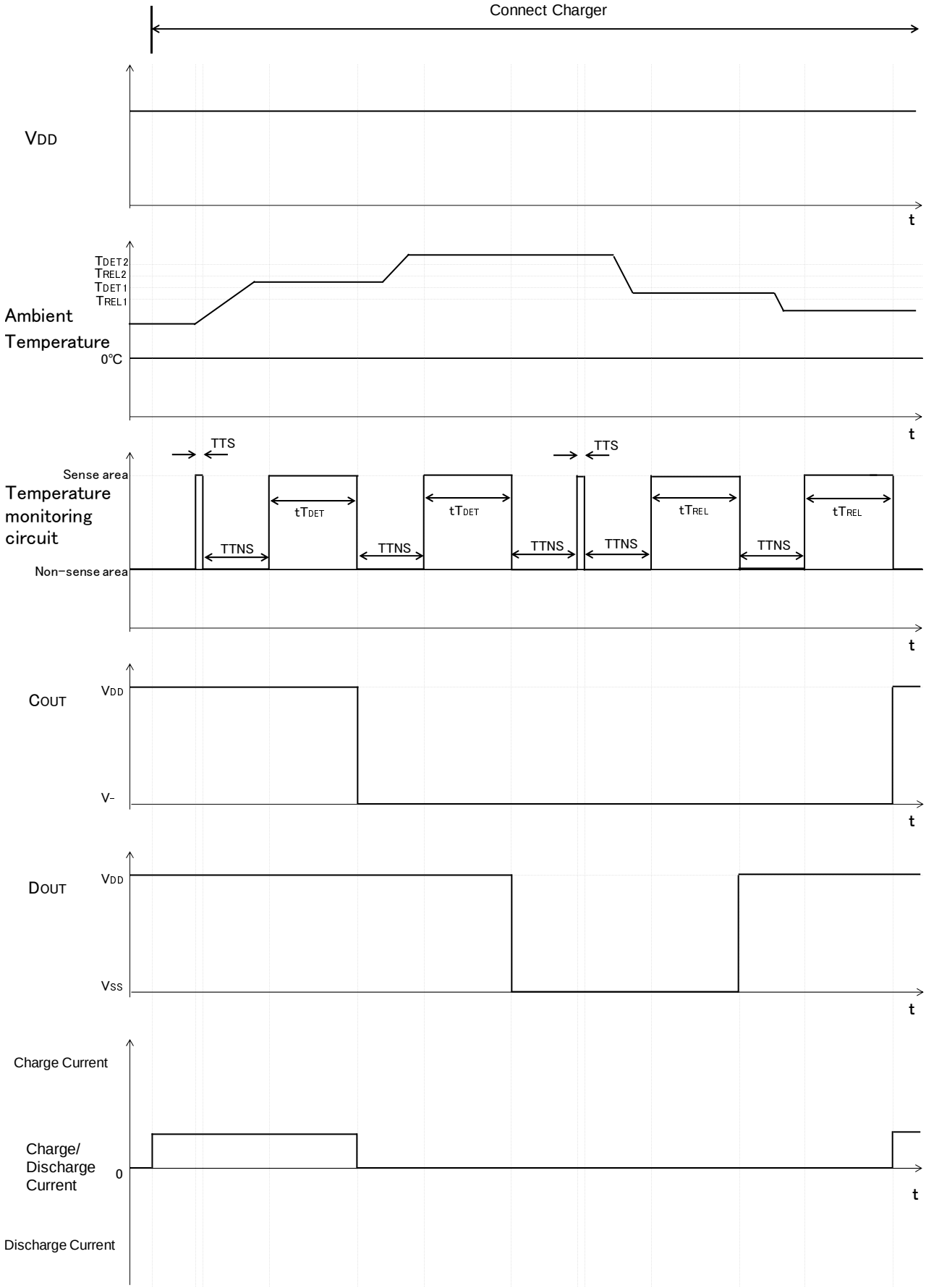
(1) Timing diagram of over-charge voltage



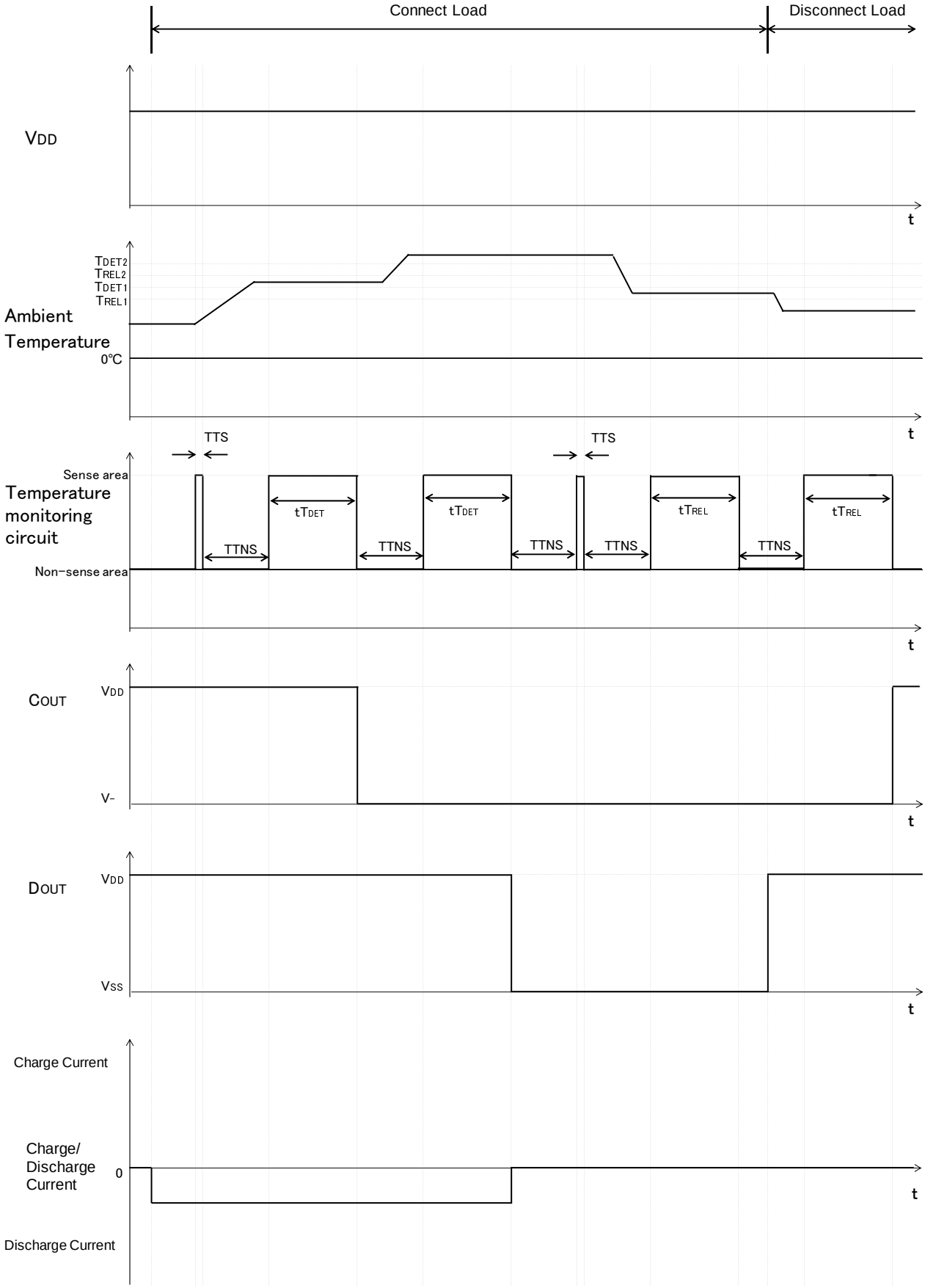
(2) Over-discharge, Excess discharge current, Short circuit



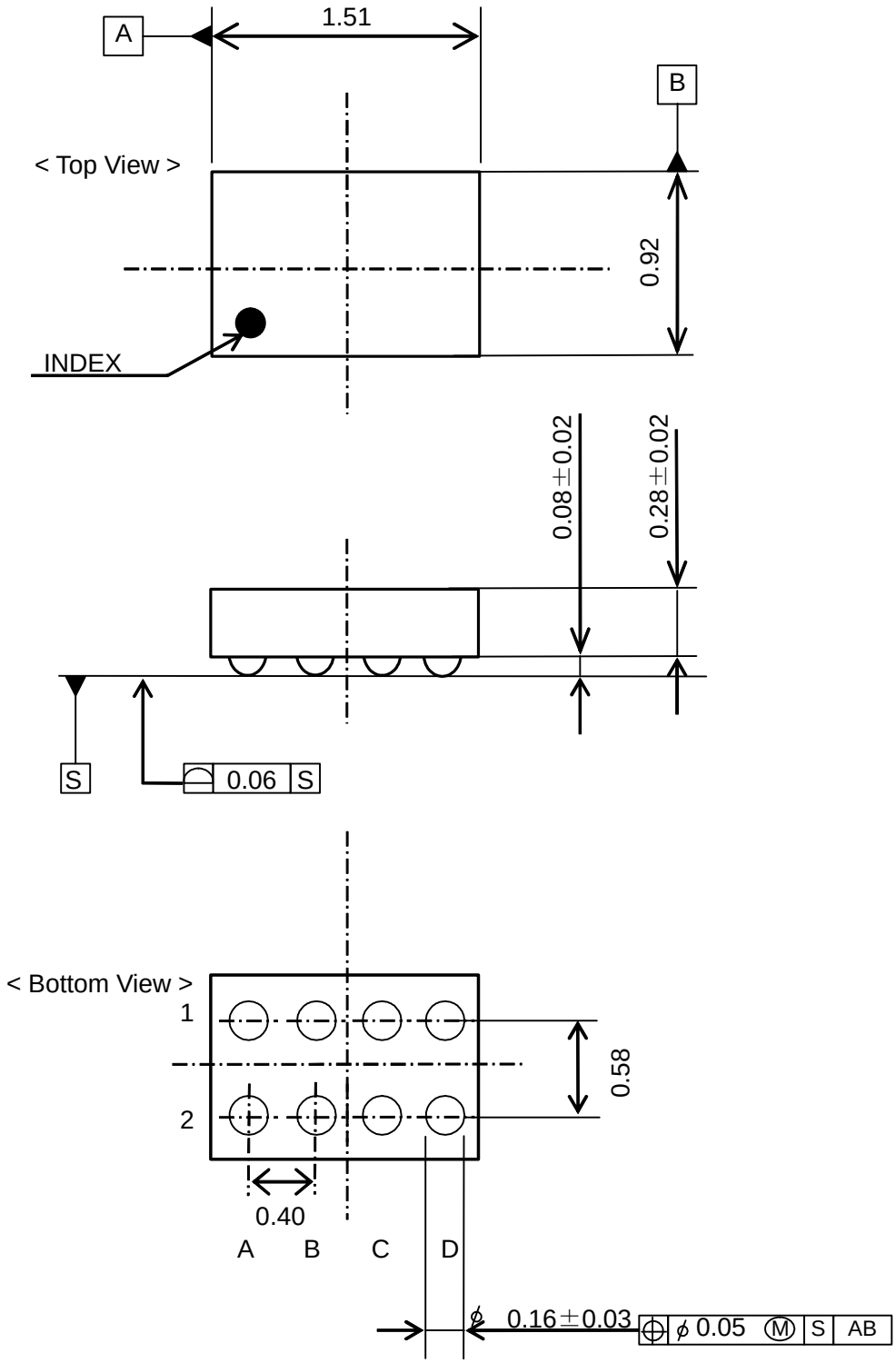
(3) Thermal protection (Connect Charger)



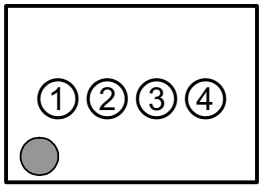
(4) Thermal protection (Connect Load)



[10] Package Dimensions WLCSP-8-P2



[11] Mark Specification



・Sample Marking

①②③④: Series Code Name … XXXX

・Mass Production Marking

①②: Series Code Name … XX

③④: Lot Number (Alphanumeric serial number)

[12] R5441 Series Selection

■ Detector threshold range

- Over-charge detector threshold ..... 4.2V~4.6V step of 0.005V (Trimming Option)
- Over-discharge detector threshold ..... 2.0V~3.4V step of 0.005V (Trimming Option)
- Excess discharge current threshold ..... 0.015V~0.150V (Trimming Option)
  step of 0.001V (0.015V to 0.050V)
  step of 0.005V (0.050V to 0.150V)
- Short current threshold ..... 0.040V~0.280V (Trimming Option)
- Excess charge current threshold ..... -0.150V~-0.015V (Trimming Option)
  step of 0.001V (-0.030V to -0.015V)
  step of 0.005V (-0.150V to -0.030V)
- Thermal detector threshold ..... 40℃~70℃ step of 5℃ (Trimming Option) *Note1

■ Detector threshold accuracy (Unless otherwise provided, Ta=25°C)

- Over-charge detector threshold ..... ±10mV (Ta=0℃ ~ +50℃)
- Over-discharge detector threshold ..... ±2.0%
- Excess discharge current threshold ..... ±3mV (0.015V to 0.030V)
  ±10% (0.031V to 0.050V)
  ±5mV (0.051V to 0.150V)
- Short current threshold ..... ±5mV
- Excess charge current threshold ..... ±4mV (-0.020V to -0.015V)
  ±20% (-0.040V to -0.021V)
  ±8mV (-0.150V to -0.040V)
- Thermal detector threshold ..... ±3℃*Note1

■ Output delay time

- Over-charge detector output delay ..... 1.0s (Fixed value)
- Over-discharge detector output delay ..... 16ms/32ms/128ms (Trimming Option)
- Excess discharge current detector output delay ..... 8ms/16ms/32ms/128ms/256ms/512ms/1024ms/3072ms (Trimming Option)
- Short detector output delay ..... 280µs (Fixed value)
- Excess charge current detector output delay ..... 8ms (Fixed value)
- Thermal detector output delay (t_{TDET}) ..... 128ms/256ms/512ms/1024ms (Trimming Option)
- Thermal release output delay (t_{TREL}) ..... 128ms (Fixed value)

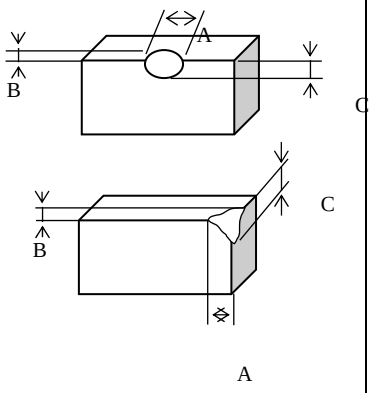
■ Functions

- 0V-battery charge option ..... available / unacceptable (Mask Option)
- Excess discharge current release option ..... auto release type / Latch type (Trimming Option)

*Note1: The R5441Z requires a NTC thermistor having a reference resistance value of 100kΩ±1% at 25°C and B-constant of 4250K±1%.

[13] Visual Inspection Criteria

<WLCSP>

No.	INSPECTION ITEMS	INSPECTION CRITERIA	FIGURE
1	Package chipping	A≥0.2mm is rejected B≥0.2mm is rejected C≥0.2mm is rejected And, Package chipping to Si surface and to bump is rejected.	
2	Si surface chipping	A≥0.2mm is rejected B≥0.2mm is rejected C≥0.2mm is rejected But, even if A≥0.2mm, B≤0.1mm is acceptable.	
3	No bump	No bump is rejected.	
4	Marking miss	To reject incorrect marking, such as another product name marking or another lot No. marking	
5	No marking	To reject no marking on the package	
6	Reverse direction of marking	To reject reverse direction of marking character	
7	Defective marking	To reject unreadable marking (Microscope: X15)	
8	Scratch	To reject unreadable marking character by scratch (Microscope: X15)	
9	Stain and Foreign material	To reject unreadable marking character by stain and foreign material (Microscope: X15)	