1-Cell Li-ion Battery Protection IC with Temperature Protection

NO.EA-506-200619

OUTLINE

The R5441Z is one-cell Li-ion / polymer battery protection IC provides overcharge, overdischarge, discharge / charge overcurrent, and temperature detections. One of the features of this device is a high-accuracy detection at overcharge and overcurrent. The supply current after overdischarge detection can be reduced to a minimum by stopping the internal circuits. The small WLCSP package is available.

FEATURES

- Absolute Maximum Ratings ····· 12 V
- Supply Current at Normal Mode ····· Typ.3.5 µA
- Standby Current ····· Max.0.04 µA

Detector Selectable Range and Accuracy (Unless otherwise provided, Ta=25°C)

- Overcharge Detection Voltage ····· 4.2 V to 4.6 V (in 0.005 V step, ±10 mV [(1)])
- Overdischarge Detection Voltage ····· 2.0 V to 3.4 V (in 0.005 V step, ±2.0%)
- Discharge Overcurrent Detection Voltage ····· 0.015 V to 0.150 V
  (0.015 V to 0.050 V in 0.001 V step /
  0.050 V to 0.150 V in 0.005 V step,
  0.015 V to 0.030 V: ±3mV /
  0.030 V to 0.050 V: ±10% /
  0.050 V to 0.150 V: ±5mV)
- Charge Overcurrent Detection Voltage ····· -0.150 V to -0.015V
  (-0.030 V to -0.015 V in 0.001 V step /
  -0.150 V to -0.030 V in 0.005 V step,
  -0.020 V to -0.015 V): ±4mV /
  -0.040 V to -0.020 V: ±20% /
  -0.150 V to -0.040 V: ±8mV)
- Short-circuit Detection Voltage ····· 0.040 V to 0.280 V (in 5mV step, ±5mV)
- Thermal Detection Temperature[(2)] ····· R5441ZxxxN/P: 50°C to 85°C (in 5°C step, ±3°C)
  R5441ZxxxV/W: 40°C to 75°C (in 5°C step, ±3°C)
- Thermal Release Hysteresis Temperature ····· 0°C to 5°C (in 1°C step)

Internal Fixed Output Delay Time

- Overcharge Detection Delay Time (t_{VDET1}) ····· 1.0 s
- Overdischarge Detection Delay Time (t_{VDET2}) ····· 16 ms / 32 ms / 128 ms

(1) When 0°C ≤ Ta ≤ 50°C

(2) The R5441Z requires a NTC thermistor having a reference resistance value of 100kΩ or 470kΩ ±1% at 25°C and B-constant of 4250K±1%.

- Discharge Overcurrent Detection Delay Time (t_{VDET3}) ·· 8 ms / 16 ms / 32 ms / 128 ms / 256 ms / 512 ms / 1024 ms / 3072 ms
- Short-circuit Detection Delay Time (t_{SHORT}) ····· 280 µs
- Charge Overcurrent Detection Delay Time (t_{VDET4}) ····· 8 ms
- Thermal Detection Delay Time (t_{TDET})····· 128 ms / 256 ms / 512 ms / 1024 ms
- Thermal Release Delay Time (t_{TREL}) ····· 128 ms

Optional Functions

- 0 V-battery Charging ····· Available or Unavailable
- Hysteresis for Overdischarge Release Voltage····· Available or Unavailable
- Discharge Overcurrent Release Conditions····· Auto Release Type or Latch Type
- Resistance of Thermistors····· 100kΩ / 470kΩ

APPLICATIONS

- Li+ / Li- Polymer protector of Overcharge, Overdischarge, and Overcurrent for Battery pack
- High precision protectors for smart-phones and any other electronic gadgets using on-board Li+ / Li-Polymer battery

SELECTION GUIDE

Overcharge and Overdischarge voltages, and Discharge overcurrent are user-selectable.

Selection Guide

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R5441Zxxx$∗-E2-F	WLCSP-8-P2	5,000 pcs	Yes	Yes

xxx: Specify a code combined the set output voltages. Refer to *"Product Code List"* for details.

$: Specify a delay time version from the table below.

Ver.	t_{VDET1} (ms)	t_{VDET2} (ms)	t_{VDET3} (ms)	t_{VDET4} (ms)	t_{VREL1} (ms)	$t_{VREL2/3}$ (ms)	t_{VREL4} (ms)	t_{SHORT} (µs)	t_{TDET} (ms)	t_{TREL} (ms)	t_{TS} (ms)	t_{TNS} (ms)
A	1024	128	512	8	16	1.1	1.1	0.28	128	128	10	90
B	1024	32	512	8	16	1.1	1.1	0.28	128	128	10	90
E	1024	16	32	8	16	1.1	1.1	0.28	128	128	10	90
G	1024	32	512	8	16	1.1	1.1	0.28	1024	128	10	90
H	1024	32	1024	8	16	1.1	1.1	0.28	1024	128	10	90
J	1024	128	128	8	16	1.1	1.1	0.28	128	128	10	90
K	1024	16	8	8	16	1.1	1.1	0.28	512	128	10	90
L	1024	32	32	8	16	1.1	1.1	0.28	1024	128	10	390
M	1024	32	32	8	16	1.1	1.1	0.28	1024	128	10	390
N	1024	32	16	8	16	1.1	1.1	0.28	1024	128	10	390
U	1024	128	512	8	16	1.1	1.1	0.28	1024	128	10	390
V	1024	32	512	8	16	1.1	1.1	0.28	1024	128	10	390
X	1024	32	32	8	16	1.1	1.1	0.28	1024	128	10	90

∗: Specify a version combined following functions from the table below.

Ver.	Release Conditions			0-V Charge	NTC Thermistor
	Overcharge	Overdischarge	DischargeOvercurrent		
N	Latch	Latch (with Hysteresis)	Auto Release	Unavilable	470kΩ
P	Latch	Latch (with Hysteresis)	Latch	Unavilable	470kΩ
V	Latch	Latch (without Hysteresis)	Auto Release	Available	100kΩ
W	Latch	Latch (without Hysteresis)	Auto Release	Unavilable	100kΩ

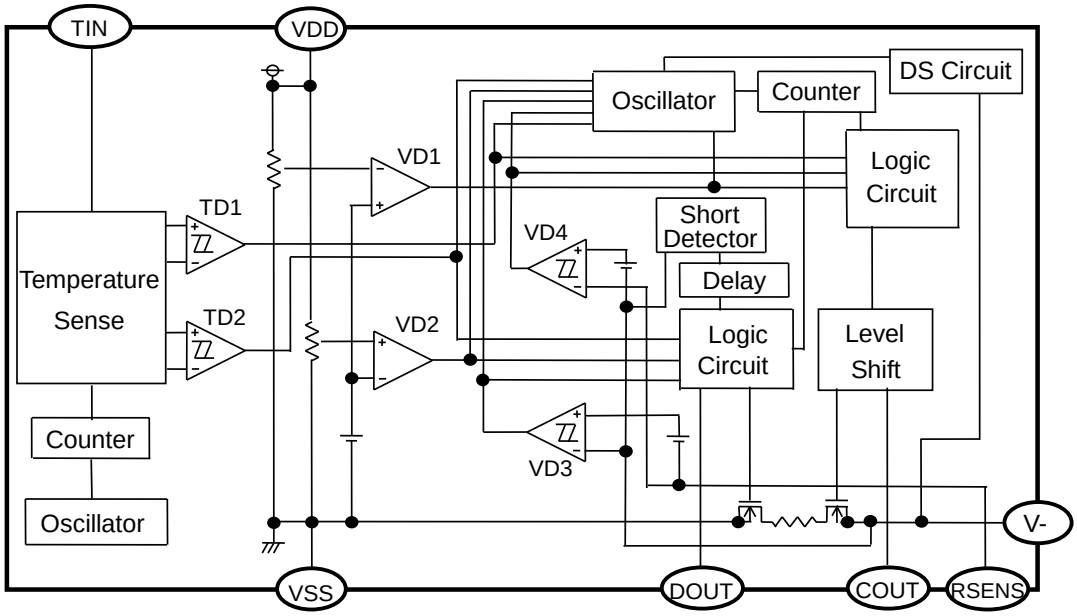
Product Code List

Product Code Table

Code	V_{DET1} (V)	V_{REL1} (V)	V_{DET2} (V)	V_{REL2} (V)	V_{DET3} (V)	V_{DET4} (V)	V_{SHORT} (V)	T_{DET1} (°C)	T_{DET2} (°C)	t_{VDET2} (ms)	t_{VDET3} (ms)	R_{TH} (kΩ)	0-V Charge (Yes/No[1])
R5441Z**201**MV	4.450	-	2.450	2.450	0.017	-0.015	0.040	45	45	32	32	100	Yes
R5441Z**201**MW	4.450	-	2.450	2.450	0.017	-0.015	0.040	45	45	32	32	100	No
R5441Z**202**MW	4.450	-	2.450	2.450	0.017	-0.015	0.040	50	50	32	32	100	No
R5441Z**203**XN	4.440	-	2.450	2.720	0.035	-0.030	0.080	80	80	32	32	470	No
R5441Z**207**LV	4.260	-	2.400	2.400	0.015	-0.015	0.040	45	60	32	32	100	Yes
R5441Z**208**NV	4.430	-	2.600	2.600	0.035	-0.035	0.060	70	70	32	16	100	Yes
R5441Z**210**NW	4.460	-	2.400	2.400	0.031	-0.025	0.060	60	70	32	16	100	No
R5441Z**211**NW	4.450	-	2.950	2.950	0.015	-0.015	0.040	60	60	32	16	100	No
R5441Z**212**MV	4.410	-	2.400	2.400	0.015	-0.015	0.040	55	55	32	32	100	Yes
R5441Z**213**NW	4.460	-	2.400	2.400	0.035	-0.026	0.060	65	75	32	16	100	No
R5441Z**214**NW	4.460	-	2.400	2.400	0.035	-0.026	0.060	75	75	32	16	100	No
R5441Z**215**MV	4.400	-	2.500	2.500	0.015	-0.015	0.040	65	65	32	32	100	Yes
R5441Z**216**VW	4.500	-	2.400	2.400	0.020	-0.017	0.040	75	75	32	512	100	No
R5441Z**217**UW	4.460	-	2.500	2.500	0.035	-0.031	0.060	70	70	128	512	100	No
R5441Z**218**MV	4.400	-	2.500	2.500	0.015	-0.015	0.040	50	50	32	32	100	Yes
R5441Z**219**UW	4.460	-	2.200	2.200	0.035	-0.031	0.060	70	70	128	512	100	No
R5441Z**220**LV	4.260	-	2.400	2.400	0.015	-0.015	0.040	55	60	32	32	100	Yes

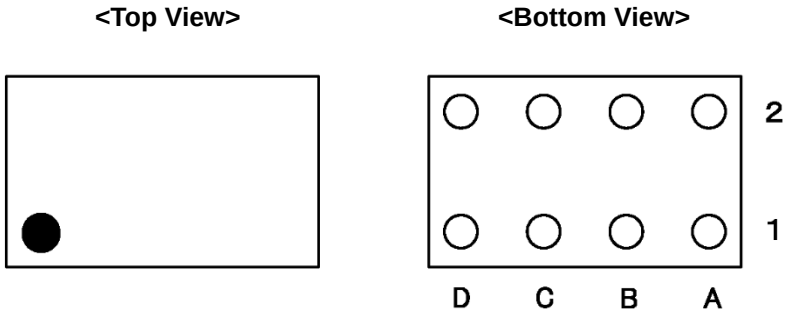
(1) "No" means the 0 V battery charging is prohibited.

Block Diagram



R5441Z Block Diagram

PIN DESCRIPTION



R5441Z (WLCSP-8-P2) Pin Configuration

R5441Z Pin Description

Pin No.	Symbol	Pin Description
A1	V-	Charger negative input pin
B1	VDD	Power supply pin, Substrate level in IC
C1	NC	No connection
D1	VSS	Ground pin
A2	COUT	Overcharge detection pin, CMOS output
B2	RSENS	Overcurrent detection input pin
C2	TIN	Temperature detection input pin
D2	DOUT	Discharge detection pin, CMOS output

ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings (Ta = 25°C, V_{SS} = 0 V)

Symbol	Parameter	Rating	Unit
V_{DD}	Supply Voltage	-0.3 to 12	V
V−	V− Pin Voltage	V_{DD} - 30 to V_{DD} + 0.3	V
R_{SENSE}	RSENSE Pin Voltage	V_{DD} - 30 to V_{DD} + 0.3	V
V_{TIN}	TIN Pin Voltage	V_{SS} - 0.3 to V_{DD} + 0.3	V
V_{COUT}	COUT Pin Voltage	V_{DD} - 30 to V_{DD} + 0.3	V
V_{DOUT}	DOUT Pin Voltage	V_{SS} - 0.3 to V_{DD} + 0.3	V
P_D	Power Dissipation	150	mW
Tj	Junction Temperature Range	−40 to 125	°C
Tstg	Storage Temperature Range	−55 to 125	°C

ABSOLUTE MAXIMUM RATINGS

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause permanent damage and may degrade the lifetime and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings is not assured.

RECOMMENDED OPERATING CONDITIONS

Recommended Operating Conditions

Symbol	Parameter	Rating	Unit
V_{DD1}	Operating Input Voltage	1.5 to 5.0	V
Ta	Operating Temperature Range	−40 to 85	°C

RECOMMENDED OPERATING CONDITIONS

All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

ELECTRICAL CHARACTERISTICS

R5441Zxxxxx Electrical Characteristics (Ta = 25°C)

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit	Test Circuit(1)
V_{DD1}	Operating Input Voltage	V_{DD} - V_{SS}		1.5		5.0	V	A
V_{ST}	Minimum Operating Voltage at 0 V Charging	Voltage Defined as V_{DD} - V−, V_{DD} - V_{SS} = 0 V				1.8	V	A
V_{NOCHG}	Maximum Operating Voltage at Charging Inhibition (Disabled 0 V Charging)	Voltage Defined as V_{DD} - V_{SS}, V_{DD} - V− = 4 V		1.00	1.25	1.50	V	A
V_{DET1}	Overcharge Detection Voltage	R1 = 330 Ω, 0 °C ≤ Ta ≤ 50 °C (2)		V_{DET1} −0.010	V_{DET1}	V_{DET1} +0.010	V	B
t_{VDET1}	Overcharge Detection Delay Time	V_{DD} = 3.6 V → 4.6 V		0.80	1.00	1.20	s	B
t_{VREL1}	Overcharge Release Delay Time	V_{DD} = 4V, V- = 0V → 1V		12.0	16.0	20.0	ms	C
V_{DET2}	Overdischarge Detection Voltage	Detect falling edge of supply voltage		V_{DET2} ×0.98	V_{DET2}	V_{DET2} ×1.02	V	D
t_{VDET2}	Overdischarge Detection Delay Time	V_{DD} = 3.6 V to 2.0 V		tV_{DET2} ×0.80	t_{VDET2}	t_{VDET2} ×1.20	ms	D
t_{VREL2}	Overdischarge Release Delay Time	V_{DD} = 3.6 V, V- = 3.6 V → 0 V		0.85	1.10	1.35	ms	E
V_{DET3}	Discharge Overcurrent Detection Voltage	Detect rising edge of V- pin voltage	0.015 V to 0.030 V	V_{DET3} -0.003	V_{DET3}	V_{DET3} +0.003	V	F
			0.031 V to 0.050 V	V_{DET3} ×0.900		V_{DET3} ×1.100		
			0.051 V to 0.150 V	V_{DET3} -0.005		V_{DET3} +0.005		
V_{REL3}	Discharge Overcurrent Release Voltage	V_{DD} = 3.6 V, Detect falling edge of V- pin voltage	R5441Zxxxx N/P	-0.020	0.000	0.020	V	F
			R5441Zxxxx V/W	0.050	0.200	0.350		
t_{VDET3}	Discharge Overcurrent Detection Delay Time	V_{DD} = 3.6V, V- = 0V → V_{DET3} + 0.010, V_{RSENS} = 0 V		t_{VDET3} ×0.80	t_{VDET3}	t_{VDET3} ×1.20	ms	F
t_{VREL3}	Discharge Overcurrent Release Delay Time	V_{DD} = 3.6 V, V- = 3 V → -1 V V_{RSENS} = 0 V		0.85	1.10	1.35	ms	F
V_{SHORT}	Short Protection Voltage	Detect rising edge of V- pin voltage		V_{SHORT} -0.005	V_{SHORT}	V_{SHORT} +0.005	V	F
t_{SHORT}	Short Protection Delay Time	V_{DD} = 3.6 V, V- = 0V → V_{SHORT}+0.010, V_{RSENS} = 0 V		210	280	350	µs	F
R_{SHORT}	Reset Resistance for Discharge Overcurrent Protection	V_{DD} = 3.6 V, V- = 1.0 V, V_{RSENS} = 0 V		20	45	70	kΩ	F

(1) Refer to *Test Circuit* diagrams.

(2) 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.

R5441Zxxxxx Electrical Characteristics (Continued) (Ta = 25°C)

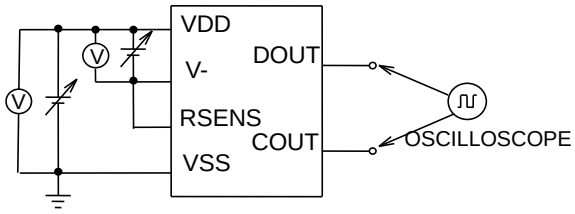
Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit	Test Circuit(1)
V_{DET4}	Charge Overcurrent Detection Voltage	Detect falling edge of V- pin voltage	-0.020 V to -0.015 V	V_{DET4} -0.004	V_{DET4}	V_{DET4} +0.004	V	F
			-0.040 V to -0.021 V	V_{DET4} ×0.800	V_{DET4}	V_{DET4} ×1.200		
			-0.150 V to -0.040 V	V_{DET4} -0.008	V_{DET4}	V_{DET4} +0.008		
t_{VDET4}	Charge Overcurrent Detection Delay Time	V_{DD} = 3.6 V, V- = 0 V → -1 V V_{RSENS} = 0 V		6	8	10	ms	F
t_{VREL4}	Charge Overcurrent Release Delay Time	V_{DD} = 3.6 V, V- = -1V → 0.3V V_{RSENS} = 0 V		0.85	1.10	1.35	ms	F
V_{DS}	Delay Time Shortening Mode Voltage	V_{DD} = 3.6 V		−2.6	−2.0	−1.4	V	G
V_{OL1}	Nch ON-Voltage of C_{OUT}	I_{OL} = 50µA, V_{DD} = 4.55 V			0.4	0.5	V	H
V_{OH1}	Pch ON-Voltage of C_{OUT}	I_{OH} = -50µA, V_{DD} = 3.9 V		3.4	3.7		V	I
V_{OL2}	Nch ON-Voltage of D_{OUT}	I_{OL} = 50µA, V_{DD} = 2.0 V			0.2	0.5	V	J
V_{OH2}	Pch ON-Voltage of D_{OUT}	I_{OH} = -50µA, V_{DD} = 3.9 V		3.4	3.7		V	K
I_{DD}	Supply Current	V_{DD} = 3.9 V, V- = V_{RSENS} = 0V			3.5	7.0	µA	L
$I_{STANDBY}$	Standby Current	V_{DD} = 1.9 V				0.04	µA	L
T_{DET1}	Detection Temperature 1 for External NTC (2)	[NTC performance] R5441ZxxxxN / P Resistance:470kΩ±1%(25°C) B-Constant: 4250K±1%		T_{DET1} -3.0	T_{DET1}	T_{DET1} +3.0	°C	P
T_{REL1}	Release Temperature 1 for External NTC (2)			T_{REL1} -3.0	T_{REL1}	T_{REL1} +3.0	°C	P
T_{DET2}	Detection Temperature 2 for External NTC (2)	R5441ZxxxxV / W Resistance:100kΩ±1%(25°C) B-Constant: 4250K±1%		T_{DET2} -3.0	T_{DET2}	T_{DET2} +3.0	°C	Q
T_{REL2}	Release Temperature 2 for External NTC (2)			T_{REL2} -3.0	T_{REL2}	T_{REL2} +3.0	°C	Q
R_{TIN}	Internal Resistance for Temperature Sense	R5441ZxxxxN / P		93	150	207	kΩ	R
		R5441ZxxxxV / W		59	96	133		
t_{TS}	Temperature Sense Time	V_{DD}=3.6V		8	10	12	ms	R
t_{TDET}	Detection Temperature Delay Time	V_{DD}=3.6V		t_{TDET} ×0.80	t_{TDET}	t_{TDET} ×1.20	ms	P,Q
t_{TREL}	Release Temperature Delay Time	V_{DD}=3.6V		102	128	154	ms	P,Q
t_{TNS}	Temperature Non-sense Time	V_{DD}=3.6V	R5441ZxxxxN/P	72	90	108	ms	R
			R5441ZxxxxV/W	312	390	468		

(1) Refer to *Test Circuit* diagrams.

(2) This specification is guaranteed by design.

Test Circuits

A



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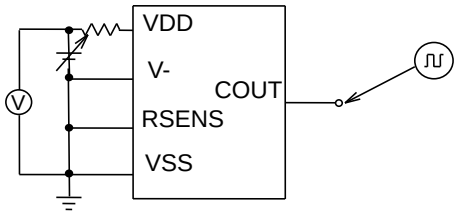

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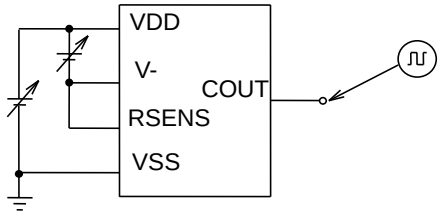

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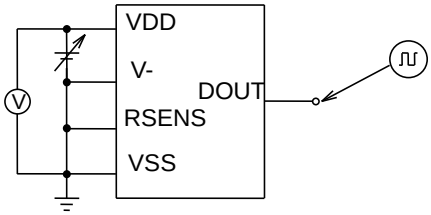

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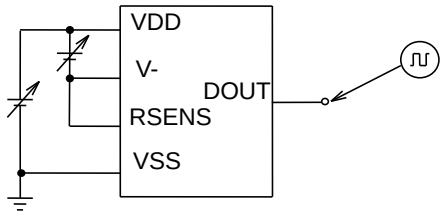

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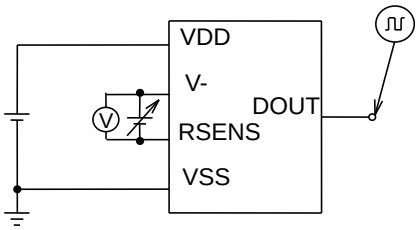

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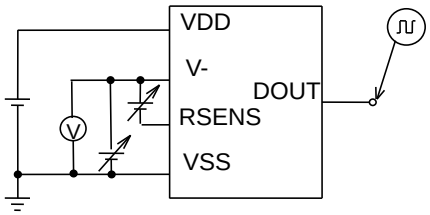

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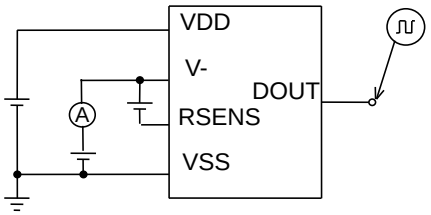

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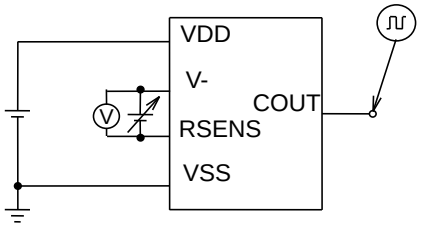

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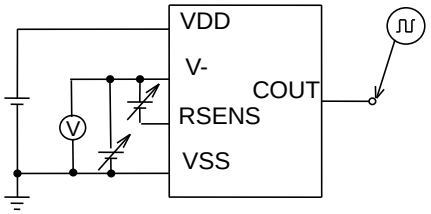

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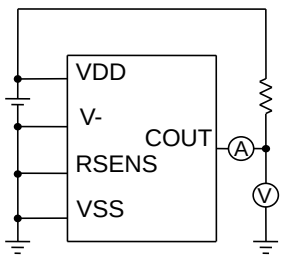

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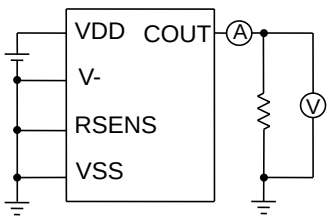

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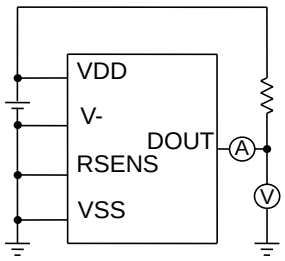
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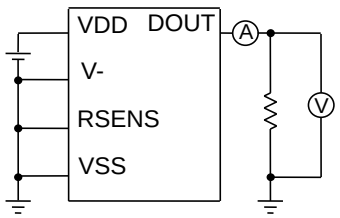
DOUT
RSENS
VSS
A
V

N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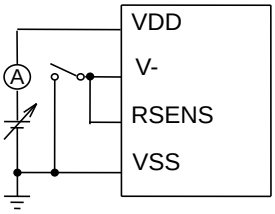
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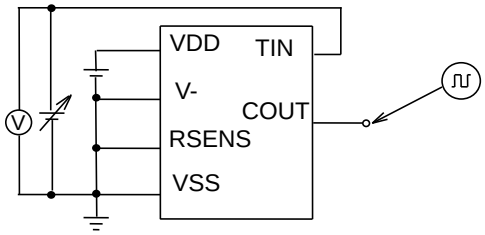
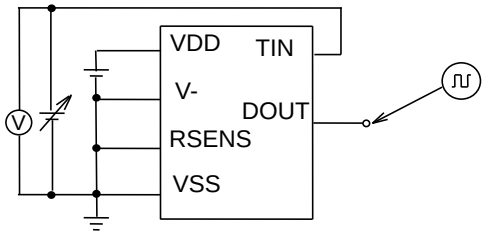

VDD
TIN
V-
COUT
RSENS
VSS
V

Q


VDD
TIN
V-
DOUT
RSENS
VSS
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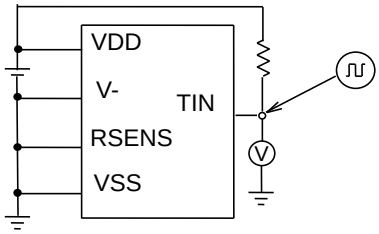
R


VDD
V-
TIN
RSENS
VSS
V

THEORY OF OPERATION

VD1: Overcharge Detector

The VD1 monitors the VDD pin voltage (V_{DD}) during charge. When V_{DD} becomes more than or equal to the overcharge detector threshold (V_{DET1}), the VD1 senses the overcharge condition, the COUT pin becomes “low”. The VD1 stops charging by turning off the external Nch.MOSFET. When V_{DD} becomes lower than overcharge detection voltage (V_{DET1}) under the overcharge condition, the release condition may be not enough depending on the characteristics of external components such as MOSFETs and some load must be set to release the overcharge. Then, the COUT pin becomes “high” and the battery charger can recharge by turning on the external Nch.MOSFET. In other words, even if the cell voltage becomes lower than V_{DET1} under the overcharge condition, the battery is not recharged while a charger is connected to the battery pack. Therefore, there is no hysteresis for VD1. The discharge overcurrent detector (VD3) can determine whether load is set or not. In other words, the V- pin voltage becomes more than or equal to the discharge overcurrent release voltage (V_{REL3}) by connecting a load and the overcharge condition is released.

When V_{DD} becomes more than or equal to V_{DET1}, if a load is connected to the battery pack while the charger is disconnected, the COUT pin will become “low”. Then, a load current might flow via a parasitic diode of the external Nch.MOSFET. If V_{DD} becomes lower than V_{DET1}, the COUT pin will become “high”.

Output delay times for overcharge detection and release are internally fixed respectively. If V_{DD} becomes lower than V_{DET1} within the overcharge detection delay time (t_{VDET1}) after exceeding V_{DET1}, the VD1 will not be in the overcharge condition. As a level shifter is built in a buffer driver for the COUT pin, the “low” level is equal to the voltage level of V- pin. The COUT pin is a CMOS output type and its output level is in between VDD and V-.

VD2: Overdischarge Detector

The VD2 monitors the VDD pin voltage (V_{DD}) during discharge. When V_{DD} becomes less than or equal to the overdischarge detector threshold (V_{DET2}), the VD2 senses the overdischarge condition and stop discharging by turning off the external Nch.MOSFET. The charger must be connected to the battery in order to release from the overdischarge condition while the DOUT pin is "high". If V_{DD} becomes less than V_{DET2} with connecting the charger, the charge current will flow via a parasitic diode of the external Nch.MOSFET. After that, when V_{DD} becomes more than V_{DET2}, the DOUT pin becomes "high" and the charger can discharge by tuning on the external Nch.MOSFET. A charger operation when a cell voltage is equal to 0 V differs according to the function version.

R5441xxxxV: When a cell voltage is equal to 0 V, the COUT pin become "high" by connecting a charger to the battery pack, and the system is allowed to charge while the voltage of the charger is more than the maximum limit of the minimum operating voltage (V_{ST}) for 0 V charging.

R5441xxxxN/P/W: When V_{DD} is less than or equal to the maximum operation voltage at charging inhibition (V_{NOCHG}), even if a charger is connected to the battery pack, the COUT pin becomes "low" and the system is prohibited to charge.

Output delay times for overdischarge detection and release are internally fixed respectively. If V_{DD} becomes more than or equal to V_{DET2} within the overdischarge detection delay time (t_{VDET2}) after falling below V_{DET2}, the VD2 will not be in the overdischarge condition. When all circuits are halted and shift to the standby state under the overdischarge condition, the supply current would decrease to a minimum (Max. 0.1µA, V_{DD} = 1.9 V +/+-). The DOUT pin is a CMOS output type and its output level is in between V_{DD} and V_{SS}.

VD3: Discharge Overcurrent Detector, Short-Circuit Protector

The VD3 monitors the voltage level between the V- pin and the RSENS pin when charge and discharge are available with connecting to the battery pack. For some causes such as the external short-circuit, when the voltage level between the V- and the RSENS pins become more than or equal to the discharge overcurrent threshold (V_{DET3}) and less than the short detector threshold (V_{SHORT}), the VD3 senses the discharge overcurrent condition. And, when the voltage level becomes more than or equal to V_{SHORT}, the short-circuit protector works and the DOUT pin becomes “low”. VD3 protects against flowing extremely large current into the circuit by turning off an external Nch.MOSFET.

An output delay time for the discharge overcurrent detector is internally fixed. If the voltage between the V- and the RSENS pins becomes less than or equal to V_{DET3} within the output delay time, the VD3 will not be in the discharge overcurrent condition. In the case of the discharge overcurrent of the auto release type, a pull-down resistor (Typ.45kΩ) is connected between the V- and the VSS pins. After a discharge overcurrent or short circuit protection is detected, by removing a cause of overcurrent or external short-circuit, the voltage level of V- is pulled down to the V_{SS} level through the discharge overcurrent release resistor (R_{SHORT}). Then, when the voltage level between the V- and the VSS pins becomes less than or equal to the overcurrent threshold voltage, both protection circuits are released automatically. Resistor for release from discharge overcurrent is active when discharge overcurrent or short circuit is detected. The resistor is inactive in normal mode.

VD4: Charge Overcurrent Detector

The VD4 monitors the voltage level between the V- and the RSENS pins when charge and discharge are available with connecting to the battery pack. For example, if the voltage level between V- pin and RSENS pin becomes less than or equal to the charge overcurrent detector threshold (V_{DET4}), the VD4 senses the charge overcurrent condition, and the COUT becomes “low”, the VD4 protects against flowing extremely large current into the circuit by turning off an external Nch.MOSFET.

Output delay of the charge overcurrent is internally fixed. Even the voltage level of between the V- and the RSENS pins becomes less than or equal to V_{DET4}, if the voltage is higher than V_{DET4} within the delay time, the VD4 will not be in the charge overcurrent condition. Output delay time for release from the charge overcurrent is also set internally. The VD4 can be released with disconnecting a charger.

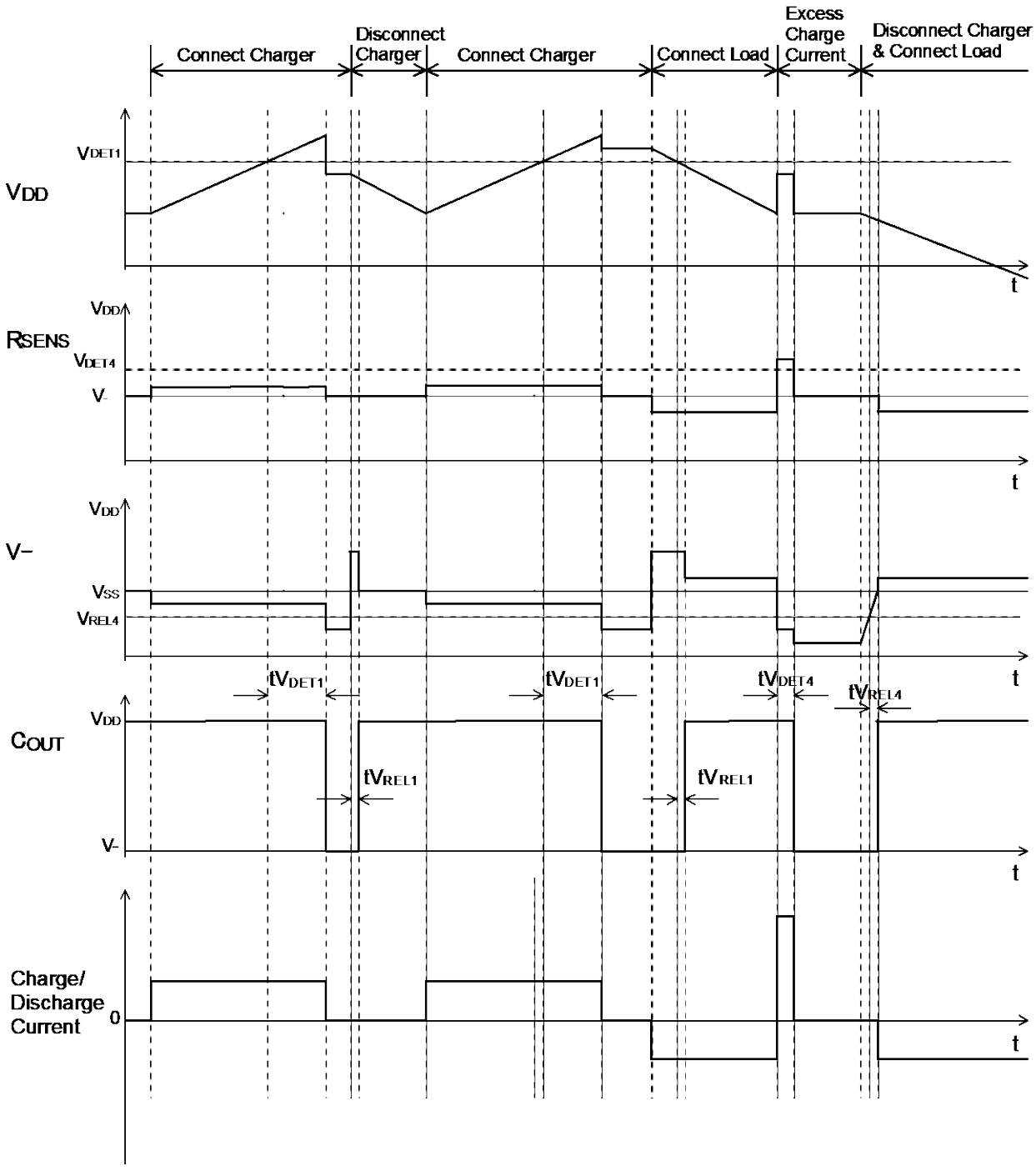
DS (Delay Shortening) Function

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

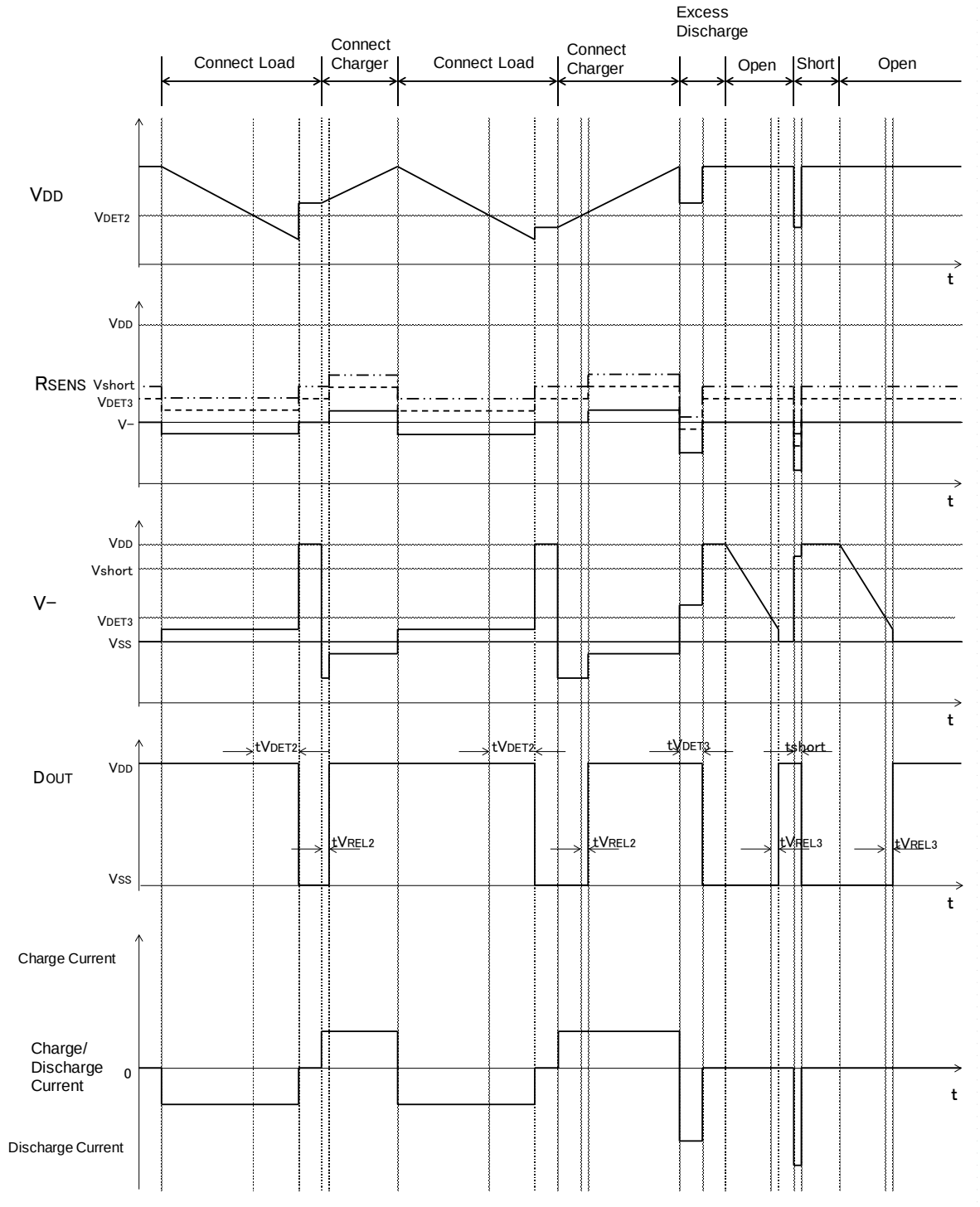
TD: Thermal Detector

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 100ms (R5441ZxxxxN/P) / 400ms (R5441ZxxxxV/W) to save the supply current. The 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, the 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. The COUT or the DOUT pin becomes “High” when the temperature decreases lower than T_{REL1} or T_{REL2}.

Timing Diagrams

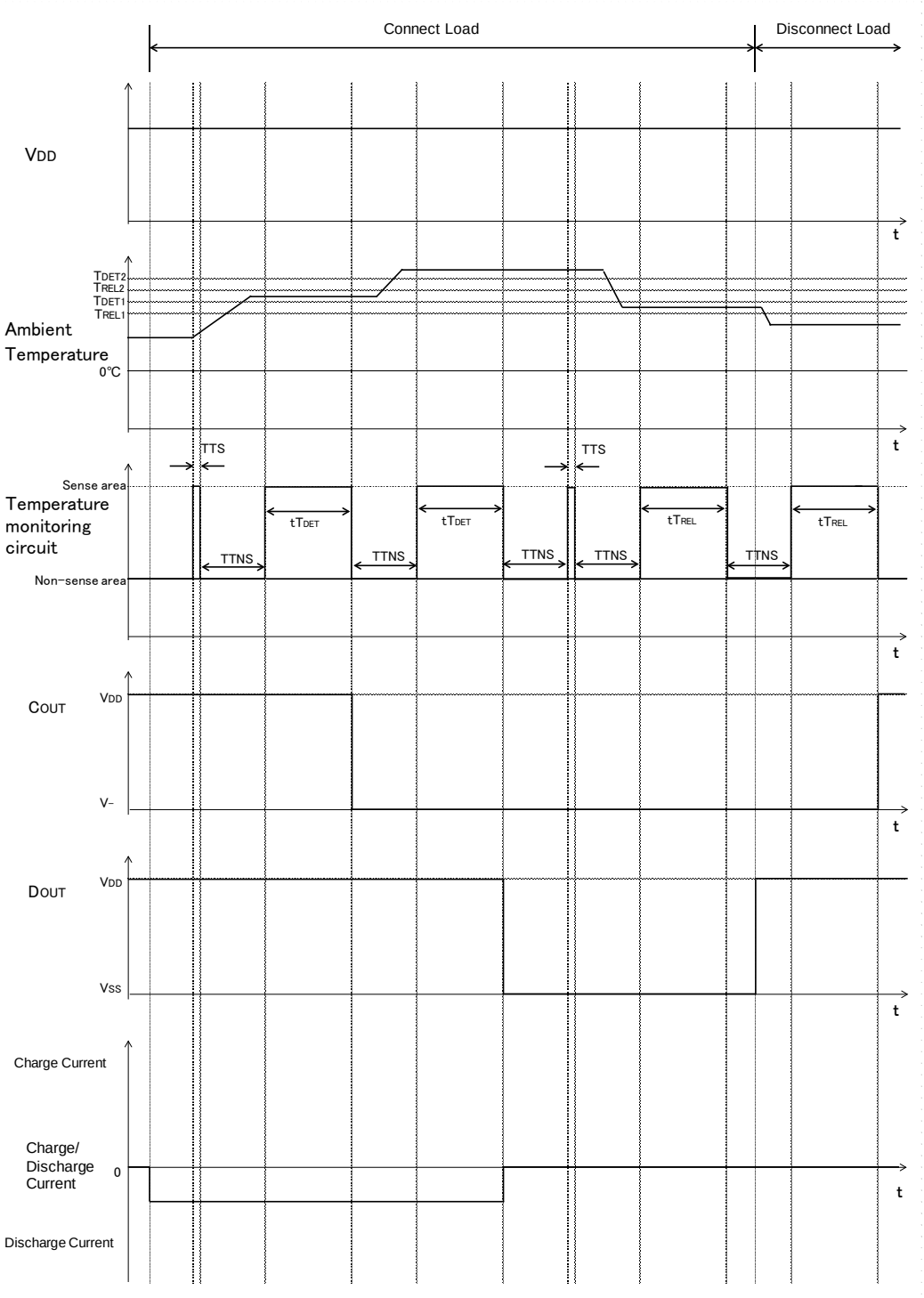


Overcharge Voltage Timing Diagram



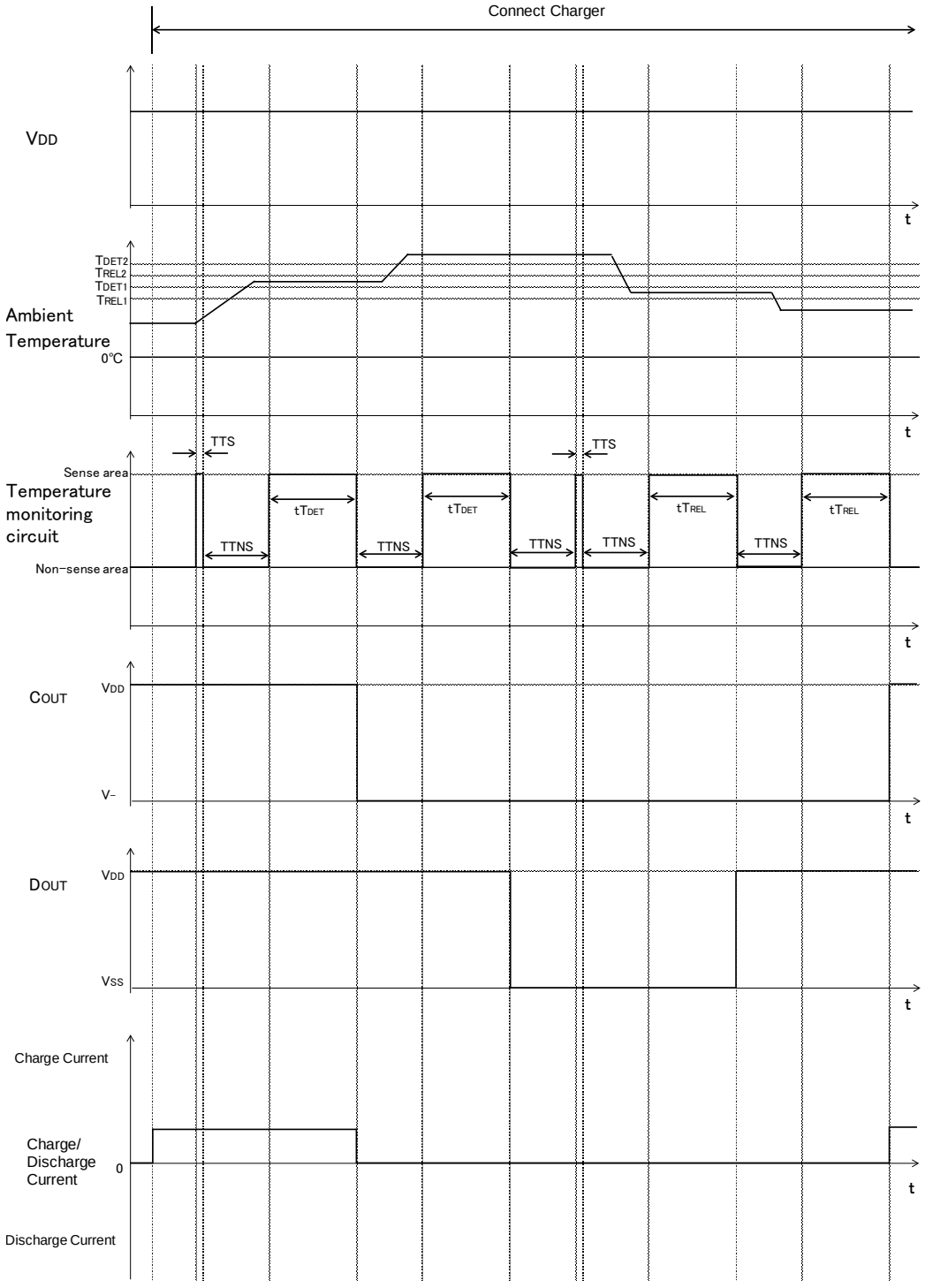
Overdischarge/ Discharge Overcurrent / Short Circuit Timing Diagrams

Thermal protection (Connected Load)



Thermal Protection Timing Chart when Connected Load

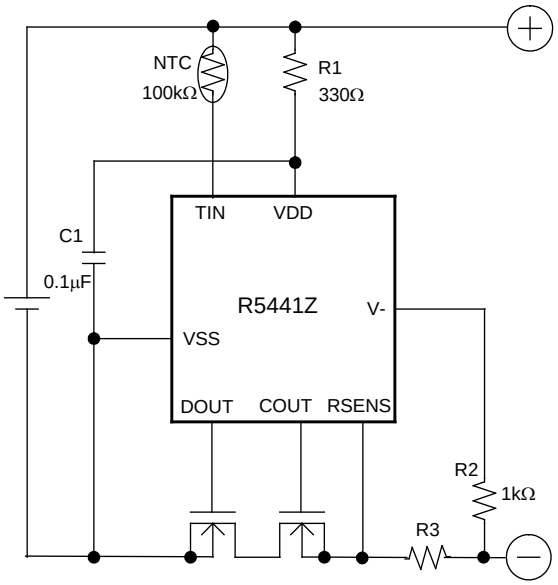
Thermal protection (Connected Charger)



Thermal Protection Timing Chart when Connected Charger

APPLICATION INFORMATION

Typical Application Circuit



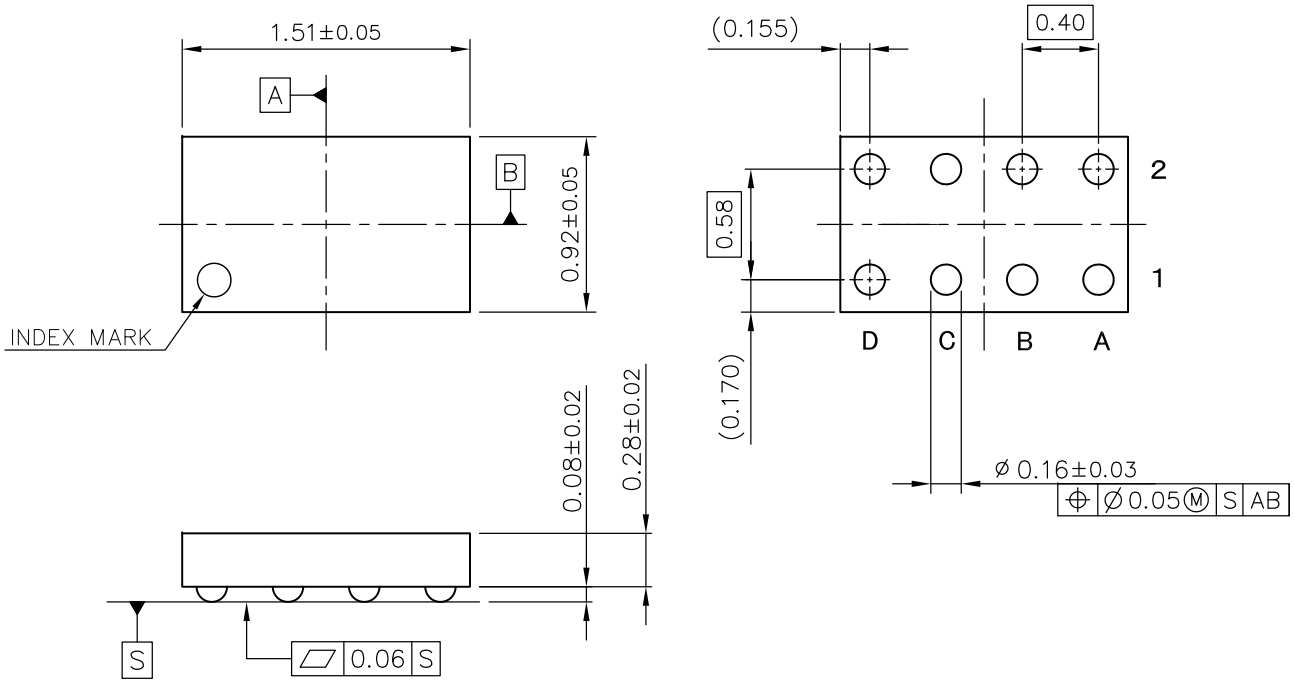
R5441Z Typical Application Circuit

R1 and C1 stabilize a supply voltage to the R5441Z. 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 R5441Z. Further, to stabilize the operation of R5441Z, 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 overcharging voltage to the R5441Z, battery pack. While small value of R1 and R2 may cause over power dissipation rating of the R5441Z, therefore a total of "R1+R2" should be 1kΩ or more. Besides, if large value of R2 is set, release from overdischarge by connecting a charger might not be possible. Recommended R2 value is equal or less than 10kΩ. R3 is a resistor for sensing an overcurrent. If the resistance value is too large, power loss becomes also large. By the overcurrent, 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 following characteristics.

NTC performance

Product Name	R5441ZxxxxN / P	R5441ZxxxxV / W
Vendor	muRata	muRata
Part Number	NCP03WF474F05RL	NCP03WF104F05RL
Resistance	470kΩ±1% (25℃)	100kΩ±1% (25℃)
B-Constant	4250K±1%	4250K±1%

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.



WLCSP-8-P2 Package Dimensions (Unit: mm)

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