Nisshinbo Micro Devices Inc.

NB7141ZA Series

1-cell Li-ion Battery Protection IC with Forced Standby and Built-In Watchdog Timer

FEATURES

- Supply Current
  - Normal mode: Typ. 2.00 µA / Max. 4.00 µA
  - Forced standby mode: Max. 0.04 µA
  - Standby mode: Max. 0.20 µA
    (V_{DET2}: Auto release type)
    Max. 0.04 µA
    (V_{DET2}: Latch type)
- Detector Selectable Range and Accuracy
  - Overcharge detection voltage (V_{DET1}):
    4.2 V to 4.7 V, ±15 mV
  - Overdischarge detection voltage (V_{DET2}):
    2.1 V to 3.2 V, ±35 mV
  - Discharge overcurrent detection voltage 1 (V_{DET31}):
    0.0050 V to 0.0300 V, ±1.0 mV
    0.0305 V to 0.0500 V, ±1.5 mV
  - Discharge overcurrent detection voltage 2 (V_{DET32}):
    0.0110 V to 0.0600 V, ±2 mV
    0.0605 V to 0.1000 V), ±4.0 %
  - Charge overcurrent detection voltage (V_{DET4}):
    –0.0050 V to –0.0300 V, ±1.0 mV
    –0.0305 V to –0.0500 V, ±1.5 mV
  - Short-circuit detection voltage 1 (V_{SHORT1}):
    0.030 V to 0.120 V, ±4.0 mV
    0.121 V to 0.200 V, ±5.0 mV
- 0 V Battery Charging selectable: Permission / Inhibition
- 0 V Battery Charging Inhibition Voltage (V_{NOCHG}):
  1.000 V to 2.500 V, ±4.0 %
- Overcharge Release Type selectable:
  Auto Release / Latch
- Overdischarge Release Type selectable:
  Auto Release / Latch
- Discharge Overcurrent Release Type selectable:
  Auto Release1 (V- = V_{DD} × 0.8 V) /
  Auto Release2 (V- = 0.070 V) /
  Latch (At charger connection)
- Discharge Overcurrent Detection Voltage 2 (V_{DET32})
  selectable: Available / Unavailable
- WDT Release Type selectable:
 Auto Release / V- rising

APPLICATIONS

Hearable / Wearable devices,
Smart Phone,
Handheld Data Terminals

GENERAL DESCRIPTION

The NB7141ZA is a 1-cell Li-ion / polymer battery protection IC which provides overcharge, over-discharge, charge / discharge overcurrent and short circuit protection, with built-in watchdog timer. The NB7141ZA can shift to the Forced Standby Mode by an external signal to STB pin to reduce own current consumption.

Low voltage and high accuracy overcurrent detection achieves a heat reduction on board by using low sense resistor. Low operating current and standby current can prolong the battery life even when its capacity is small, and the forced standby mode with STB pin too can prolong the small battery life.
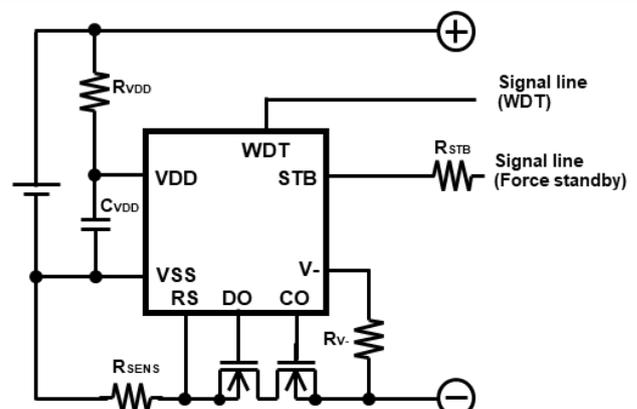The built-in watchdog timer (WDT) can monitor the MCU operating condition.
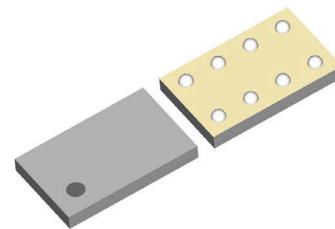
WLCSP-8-P10
1.6 × 1.0 × 0.3 [mm]

TYPICAL APPLICATION CIRCUIT

NISSHINBO

RODUCT NAME INFORMATION

NB7141 <u>ZA</u> <u>***</u> <u>*</u> <u>*</u> <u>E2</u> <u>S</u>
        aa bbb c d ee f

Description of configuration

Suffix	Item	Description
aa	Package code	Indicates the package code.
bbb		Indicates a three-digit number code that combined set voltages. Refer to the table of set voltages for details.
c	Specific option code	Indicates a delay time code. Refer to the table of delay times for details.
d		Indicates a function code. Refer to the table of functions for details.
ee	Packing	Indicates the taping code of the package. Refer to *Packing Specification* in the appendix *Package Information* for details.
f	Grade	Indicates the quality grade. Refer to the table of grade for details.

Table of set voltages (bbb)

Symbol	V_{DET1}	V_{REL1} [*1]	V_{DET2}	V_{REL2} [*1]	V_{DET31} [*2]	V_{DET32} [*2]	V_{DET4}	V_{SHORT1} [*2]	V_{NOCHG}
Voltage Range (Step) [V]	4.2 to 4.7 (0.005)	4.0 to 4.7 (0.005)	2.1 to 3.2 (0.005)	2.3 to 3.6 (0.005)	0.0050 to 0.0500 (0.0005)	0.0110 to 0.1000 (0.0005)	−0.0050 to −0.0500 (0.0005)	0.030 to 0.200 (0.001)	1.000 to 2.500 (0.05)

[*1] Under the following conditions,
    V_{REL1}: $V_{DET1} - V_{REL1} = 0.400$ V (Max.)
    V_{REL2}: $V_{REL2} - V_{DET2} = 0.700$ V (Max.)
[*2] When selecting each set voltage of V_{DET31}, V_{DET32} and V_{SHORT1}, keep from overlapping among them in consideration of
   their output voltage accuracy. Especially, V_{SHORT1} should be higher than 10 mV from V_{DET31} and V_{DET32}.

Table of delay times (c)

Symbol	t_{VDET1}	t_{VREL1}	t_{VDET2}	t_{VREL2}	t_{VDET31} [*1] type A	type B	t_{VDET32}	t_{VREL3}	t_{VDET4}	t_{VREL4}	t_{SHORT}	t_{STBD}	t_{STBR}	t_{WD}	t_{WR}
Time [ms]	1024	16	32 64 128	1.05	1024.0 2048.0 3072.0 4096.0	12.5 16.5 1024.0 4096.0	7.5 12.5 16.5	9.0	10 17	4	0.28	50 300	4.5 8.5 33.0	1024 4096 10240 25600	200 1024
C	1024	16	128	1.05	4096.0		-	9.0	10	4	0.28	300	33.0	25600	200
E	1024	16	128	1.05	4096.0		-	9.0	10	4	0.28	300	33.0	25600	1024
H	1024	16	32	1.05	1024.0		-	9.0	17	4	0.28	50	4.5	1024	200

[*1] t_{VDET31} can be selected from two types, A and B, with mask options, and each type has four patterns with trimming options.

Table of functions (d)

Function	Overcharge Release	Overdischarge Release [1]	Discharge Overcurrent Release	WDT Reset Release	Type of t_{VDET31}	Discharge Overcurrent Detection 2 (V_{DET32})	0 V Battery Charging	V_{STBD} [V]	V_{WDT} [V]
Type/ Condition	Auto Release Latch	Auto Release Latch	Auto Release1 Auto Release2 Latch	V- Rising Auto Release	A B	Available Unavailable	Permission Inhibition	0.65 0.80 1.20 1.80	0.65
H	Latch	Latch	Auto Release2	Auto Release	A	Unavailable	Inhibition	1.20	0.65
M	Latch	Latch	Auto Release1	Auto Release	B	Unavailable	Inhibition	0.65	0.65
N	Latch	Latch	Auto Release1	Auto Release	B	Unavailable	Permission	0.65	0.65
R	Auto Release	Auto Release	Auto Release1	Auto Release	B	Unavailable	Inhibition	0.65	0.65

[1] Overdischarge Release Conditions,

Auto Release: Cell voltage > V_{REL2}

Latch: Cell voltage > V_{DET2} under charger connection

Grade

| Grade	Application	Operating Temperature Range	Test Temperature
S	General-purpose and Consumer	−40°C to 85°C	25°C

ORDER INFORMATION

For details of the orderable products, please refer to the appendix *"Product Code List"*.

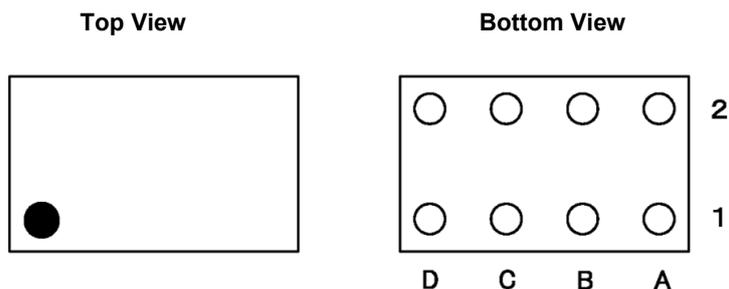| Product Name	Package	RoHS	Halogen-Free	Plating Composition	Weight [mg]	Quantity Per Reel [pcs]
NB7141ZA∗∗∗∗∗E2S	WLCSP-8-P10	Yes	Yes	Sn3.0Ag0.5Cu	0.73	5,000

Note: Contact our sales representatives for other specific option code (indicated with five asterisks).

BLOCK DIAGRAM
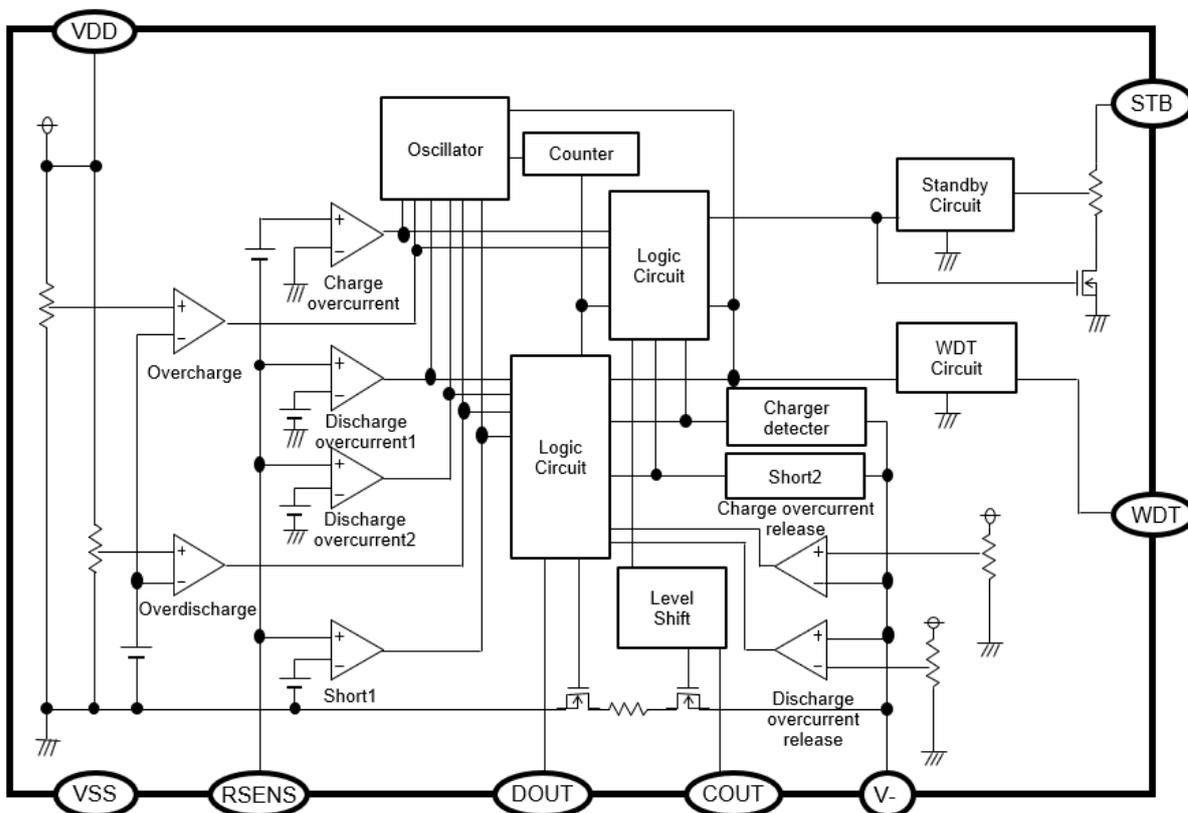
NB7141ZA Block Diagram

PIN DESCRIPTION

Top View

Bottom View

2

1

D   C   B   A

NB7141ZA (WLCSP-8-P10) Pin Configuration

Pin No.	Pin Name	I/O	Description
A1	STB	I	Forced standby instruction signal input pin
B1	V-	I	Charger negative input pin
C1	COUT	O	Charge control pin, CMOS output
D1	DOUT	O	Discharge control pin, CMOS output
A2	WDT	I	Watchdog timer signal input pin
B2	RSENS	I	Overcurrent detection input pin
C2	VDD	-	Power supply pin, the substrate level of the IC
D2	VSS	-	Ground pin for the IC

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ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit
Supply voltage	V_{DD}	−0.3 to 12	V
V- pin input voltage	V-	$V_{DD} - 30$ to $V_{DD} + 0.3$	V
RSENS pin input voltage	V_{RSENS}	$V_{SS} - 0.3$ to $V_{DD} + 0.3$	V
WDT pin input voltage	V_{WDT}	$V_{DD} - 30$ to $V_{DD} + 0.3$	V
STB pin input voltage	V_{STB}	$V_{DD} - 30$ to $V_{DD} + 0.3$	V
COUT pin output voltage	V_{COUT}	$V_{DD} - 30$ to $V_{DD} + 0.3$	V
DOUT pin output voltage	V_{DOUT}	$V_{SS} - 0.3$ to $V_{DD} + 0.3$	V
Power Dissipation	P_D	150	mW
Junction Temperature Range	Tj	−40 to 125	°C
Storage Temperature Range	Tstg	−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.

ELECTROSTATIC DISCHARGE RATINGS

Parameter	Conditions	Rating	Unit
HBM (Human Body Model)	C = 100 pF, R = 1.5 kΩ	±2000	V
CDM (Charged Device Model)	Field Included CDM (FI-CDM)	±1000	V

ELECTROSTATIC DISCHARGE RATINGS
The electrostatic discharge test is done based on JESD47. In the HBM method, ESD is applied using the power supply pin and GND pin as reference pins.

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Rating	Unit
Operating input voltage	V_{DD}	1.5 to 5.0	V
Operating temperature range	Ta	−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.

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ELECTRICAL CHARACTERISTICS

Ta = 25°C, unless otherwise noted.

NB7141ZA∗∗∗∗∗E2S Electrical Characteristics

Parameter	Symbol	Conditions			Min.	Typ.	Max.	Unit	Remark *1
Minimum charging voltage for 0 V battery charger *2	V_{STCHG}	$V_{DD} - V_{SS} = 0$ V, defined as $V_{DD} - V$-difference voltage					1.8	V	B
0 V battery charging inhibition voltage *3	V_{NOCHG}	$V_{DD} - V$- $= 4$ V, defined as $V_{DD} - V_{SS}$ difference voltage			V_{NOCHG} × 0.96	V_{NOCHG}	V_{NOCHG} × 1.04	V	A
Overcharge detection voltage	V_{DET1}	$R_{VDD} = 330\Omega$, $C_{VDD} = 0.1\mu F$			V_{DET1} − 0.015	V_{DET1}	V_{DET1} + 0.015	V	A
Overcharge release voltage	V_{REL1}	$R_{VDD} = 330\Omega$, $C_{VDD} = 0.1\mu F$			V_{REL1} − 0.045	V_{REL1}	V_{REL1} + 0.045	V	A
Overcharge detection delay time	t_{VDET1}	$V_{DD} = 3.6$ V $\rightarrow V_{DET1} + 0.1$ V			t_{VDET1} × 0.80	t_{VDET1}	t_{VDET1} × 1.20	ms	A
Overcharge release delay time	t_{VREL1}	Overcharge: Auto Release	$V_{DD} = 4.8$ V $\rightarrow V_{REL1} - 0.1$ V		12.8	16.0	19.2	ms	A
		Overcharge: Latch	$V_{DD} = 4.8$ V $\rightarrow V_{DET1} - 0.1$ V V- $= 0.2$ V						
Overdischarge detection voltage	V_{DET2}	Detect falling edge of supply voltage			V_{DET2} − 0.035	V_{DET2}	V_{DET2} + 0.035	V	C
Overdischarge release voltage	V_{REL2}	Detect rising edge of supply voltage			V_{REL2} − 0.055	V_{REL2}	V_{REL2} + 0.095	V	C
Overdischarge detection delay time	t_{VDET2}	$V_{DD} = V_{DET2} + 0.15$ V $\rightarrow V_{DET2} - 0.10$ V			t_{VDET2} × 0.80	t_{VDET2}	t_{VDET2} × 1.20	ms	C
Overdischarge release delay time	t_{VREL2}	Overdischarge: Auto Release	$V_{DD} = V_{DET2} - 0.04$ V $\rightarrow V_{REL2} + 0.1$ V		0.75	1.05	1.53	ms	C
		Overdischarge: Latch	$V_{DD} = V_{DET2} - 0.04$ V $\rightarrow V_{DET2} + 0.04$ V, V- $= 0.0$ V						
V- pin pullup resistance for V_{DET2}	R_{V-1}	$V_{DD} = 1.8$ V			0.1	0.6	1.0	MΩ	E
Discharge overcurrent detection voltage 1	V_{DET31}	$V_{DD} = 3.6$ V, Detect rising edge of V_{RSENS}	$V_{DET31} \leq 0.030$ V		V_{DET31} − 0.0010	V_{DET31}	V_{DET31} + 0.0010	V	F
			$V_{DET31} > 0.030$ V		V_{DET31} − 0.0015		V_{DET31} + 0.0015		
Discharge overcurrent detection delay time 1	t_{VDET31}	$V_{DD} = 3.6$ V, $V_{RSENS} = 0.0$ V $\rightarrow V_{DET31} + 0.005$ V			t_{VDET31} × 0.80	t_{VDET31}	t_{VDET31} × 1.20	ms	F
Discharge overcurrent detection voltage 2	V_{DET32}	$V_{DD} = 3.6$ V, Detect rising edge of V_{RSENS}	$V_{DET32} \leq 0.060$ V		V_{DET32} − 0.002	V_{DET32}	V_{DET32} + 0.002	V	F
			$V_{DET32} > 0.060$ V		V_{DET32} × 0.96		V_{DET32} × 1.04		
Discharge overcurrent detection delay time 2	t_{VDET32}	$V_{DD} = 3.6$ V, $V_{RSENS} = 0.0$ V $\rightarrow V_{DET32} + 0.005$ V			t_{VDET32} × 0.80	t_{VDET32}	t_{VDET32} × 1.20	ms	F
Short circuit detection voltage 1	V_{SHORT1}	$V_{DD} = 3.6$ V, Detect rising edge of V_{RSENS}	$V_{SHORT1} \leq 0.120$ V		V_{SHORT1} − 0.004	V_{SHORT1}	V_{SHORT1} + 0.004	V	F
			$V_{SHORT1} > 0.120$ V		V_{SHORT1} − 0.005		V_{SHORT1} + 0.005		
Short circuit detection delay time *4	t_{SHORT}	$V_{DD} = 3.6$ V, $V_{RSENS} = 0.0$ V $\rightarrow 1.0$ V			210	280	380	µs	F
Short circuit detection voltage 2	V_{SHORT2}	Detect rising edge of V-, $V_{DD} = 3.6$ V, $V_{RSENS} = 0.0$ V			V_{DD} − 2.00	V_{DD} − 1.50	V_{DD} − 0.80	V	G

*1 The test circuits for device evaluation. Refer to the section of *TEST CIRCUITS* for detail information.
*2 Only 0 V battery charging permission type
*3 Only 0 V battery charging inhibition type
*4 Short circuit release delay time is same as t_{VREL3}.

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Ta = 25°C, unless otherwise noted

NB7141ZA∗∗∗∗∗E2S Electrical Characteristics (Continued)

Parameter	Symbol	Conditions			Min.	Typ.	Max.	Unit	Remark *1
Charger detection voltage	V_{CHGDET}	Detect falling edge of V-, R_{V-} = 1.0kΩ, V_{DD} = V_{DET2} + 0.05 V			0.500	0.800	1.100	V	G
Discharge overcurrent release voltage	V_{REL3}	Detect falling edge of V-, V_{DD} = 3.6 V, V_{RSENS} = 0.0 V		Auto Release1	$V_{DD} \times 0.800 - 0.050$	$V_{DD} \times 0.800$	$V_{DD} \times 0.800 + 0.050$	V	G
				Auto Release2	0.040	0.070	0.100		
				Latch	0.040	0.070	0.100		
Discharge overcurrent release resistance	R_{SHORT}	Auto Release 1: V_{DD} = 3.6 V, V- = V_{REL3} + 0.050 V			6.5	10.0	13.5	kΩ	H
		Auto Release 2: V_{DD} = 3.6 V, V- = 0.200 V			20	45	70		
Discharge overcurrent release delay time	t_{VREL3}	V_{DD} = 3.6 V, V- = 3.6 V → 0.0 V, V_{RSENS} = 0.0 V			7.3	9.0	10.8	ms	G
Charge overcurrent detection voltage	V_{DET4}	V_{DD} = 3.6 V, Detect falling edge of V_{RSENS}	$V_{DET4} \geq -0.030$ V		$V_{DET4} - 0.0010$	V_{DET4}	$V_{DET4} + 0.0010$	V	I
			$V_{DET4} < -0.030$ V		$V_{DET4} - 0.0015$		$V_{DET4} + 0.0015$		
Charge overcurrent detection delay time	t_{VDET4}	V_{DD} = 3.6 V, V_{RSENS} = 0.0 V → −0.5 V			$t_{VDET4} \times 0.80$	t_{VDET4}	$t_{VDET4} \times 1.20$	ms	I
Charge overcurrent release voltage	V_{REL4}	Detect rising edge of V-, V_{DD} = 3.6 V, V_{RSENS} = 0.0 V			0.040	0.070	0.100	V	J
Charge overcurrent release delay time	t_{VREL4}	V_{DD} = 3.6 V, V- = −0.5 V → 1.0 V, V_{RSENS} = 0.0 V			3.2	4.0	4.8	ms	J
Forced standby detection voltage	V_{STBD}	Detect rising edge of STB, V_{DD} = 3.6 V, V- = V_{RSENS} = 0.0 V			$V_{STBD} \times 0.80$	V_{STBD}	$V_{STBD} \times 1.20$	V	K
Forced standby detection delay time	t_{STBD}	V_{DD} = 3.6 V, V_{STB} = 0.0 V → 3.6 V, V- = V_{RSENS} = 0.0 V			$t_{STBD} \times 0.80$	t_{STBD}	$t_{STBD} \times 1.20$	ms	K
Forced standby release delay time	t_{STBR}	V_{DD} = 3.6 V, V- = 3.6 V → 0.0 V, V_{STB} = V_{RSENS} = 0.0 V			$t_{STBR} \times 0.80$	t_{STBR}	$t_{STBR} \times 1.20$	ms	L
STB pin pulldown resistance	R_{STBPD}	V_{DD} = 3.6 V, V_{STB} = 3.6 V, V- = V_{RSENS} = 0 V			5.5	11.0	22.0	MΩ	M
V- pin pullup resistance in forced standby mode	R_{V-2}	V_{DD} = 3.6 V, V_{STB} = 3.6 V, V- = V_{RSENS} = 0.0 V			40	70	120	kΩ	N
WDT pin detection voltage, high / low	V_{WDT}	V_{DD} = 3.6 V, V- = V_{RSENS} = 0 V			0.45	0.65	0.85	V	O
Watchdog timeout period	t_{WD}	V_{DD} = 3.6 V, V- = V_{RSENS} = 0 V			$t_{WD} \times 0.80$	t_{WD}	$t_{WD} \times 1.20$	ms	O
Watchdog timer reset hold time	t_{WR}	Auto Release Type: V_{DD} = 3.6 V			$t_{WR} \times 0.80$	t_{WR}	$t_{WR} \times 1.20$	ms	O, P
		V- Rising Type: V_{DD} = 3.6 V, V- = 0.0 V → 3.6 V							
WDT pin input pulse width, high	t_{WDH}	V_{DD} = 3.6 V, V- = V_{RSENS} = 0 V			0.5			μs	O
WDT pin input pulse width, low	t_{WDL}	V_{DD} = 3.6V, V- = V_{RSENS} = 0 V			0.5			μs	O
V- pin current for watchdog reset hold time	I_{V-WDR}	V_{DD} = 3.6V, V- = V_{RSENS} = 0 V			-	0.1	0.2	μA	Q

*1 The test circuits for device evaluation. Refer to the section of *TEST CIRCUITS* for detail information.
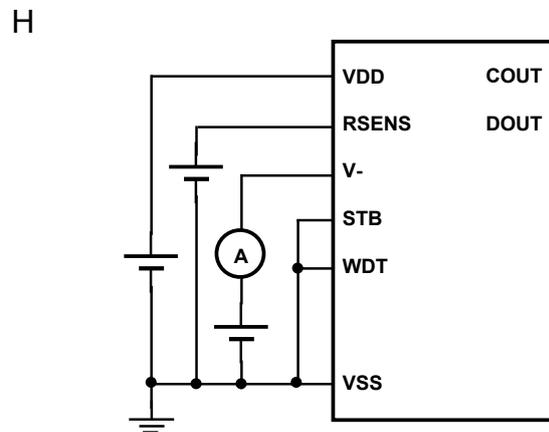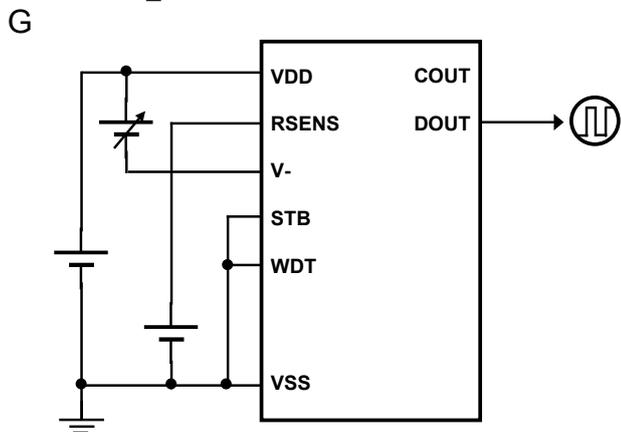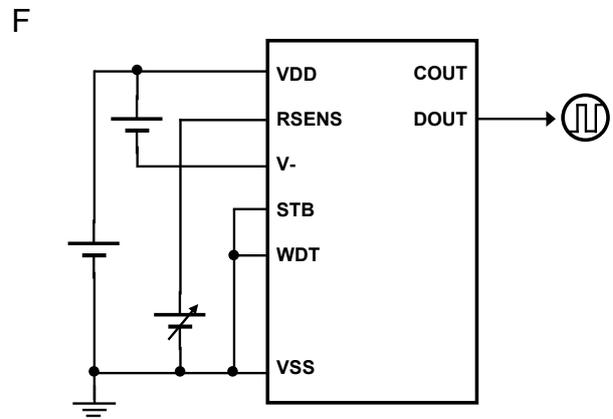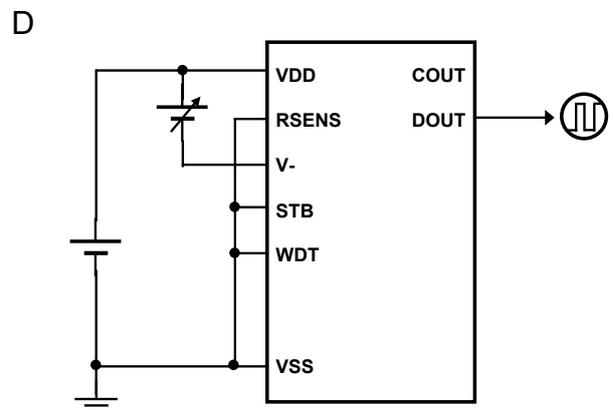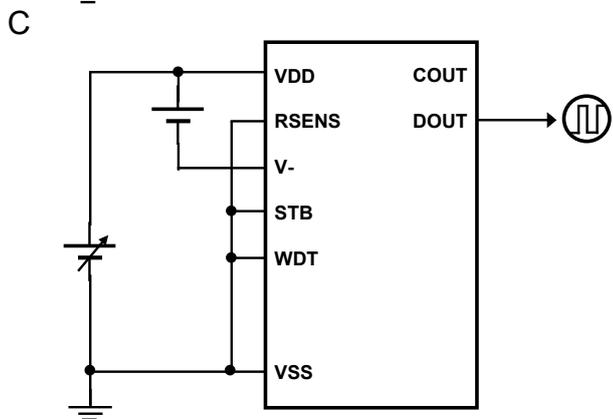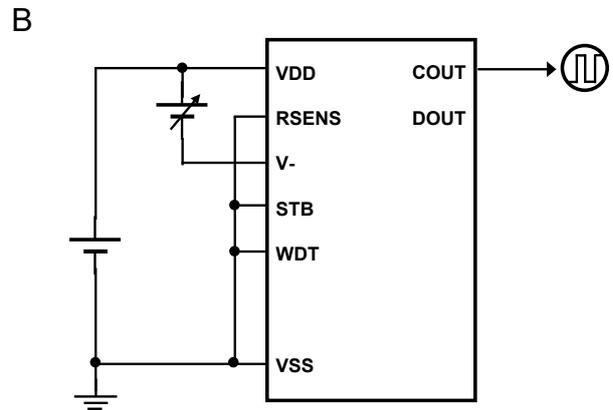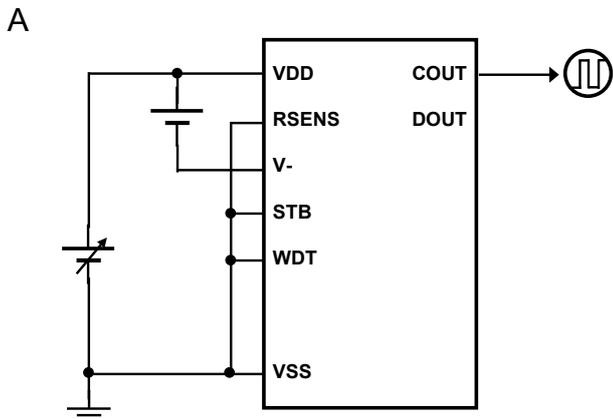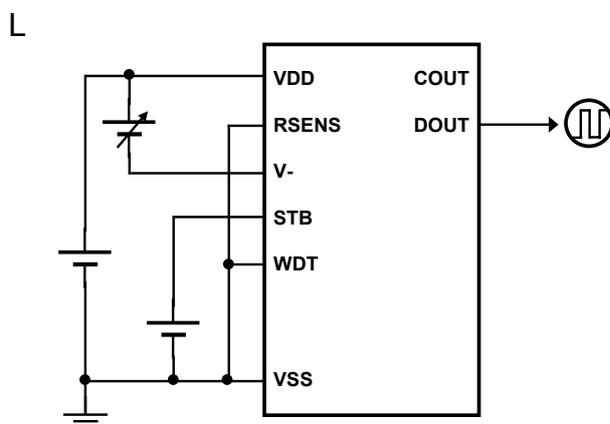
*2 Only 2nd step detection type

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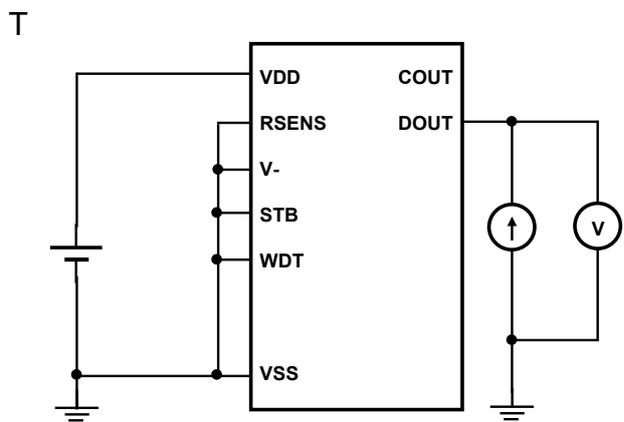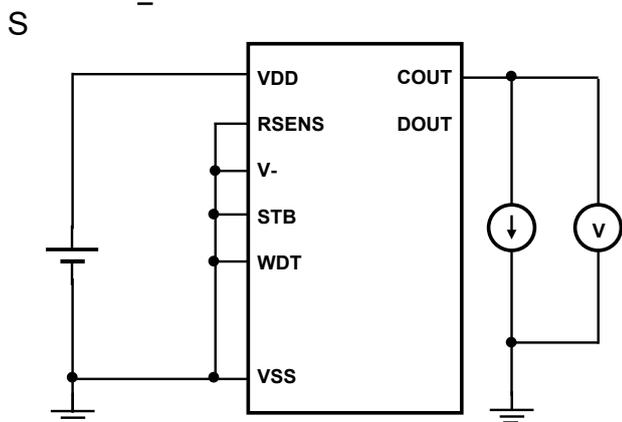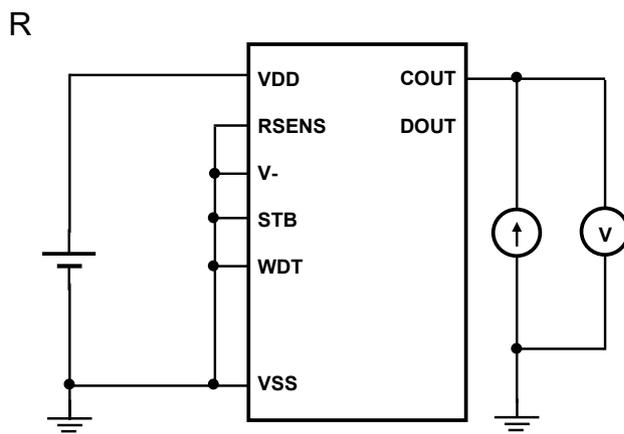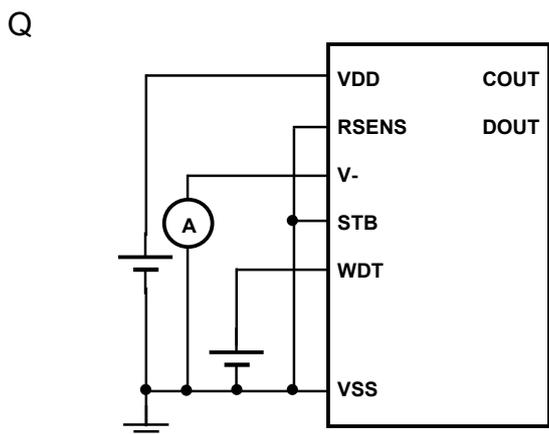Ta = 25°C, unless otherwise noted

NB7141ZA∗∗∗∗∗E2S Electrical Characteristics (Continued)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Remark *1
COUT pin NMOS ON voltage	V_{OL1}	I_{OL} = 50μA, V_{DD} = 4.80 V			0.4	0.5	V	R
COUT pin PMOS ON voltage	V_{OH1}	I_{OH} = −50μA, V_{DD} = 3.90 V		3.4	3.7		V	S
DOUT pin NMOS ON voltage	V_{OL2}	I_{OL} = 50μA, V_{DD} = 1.90 V			0.2	0.5	V	T
DOUT pin PMOS ON voltage	V_{OH2}	I_{OH} = −50μA, V_{DD} = 3.90 V		3.4	3.7		V	U
Supply current	I_{DD}	V_{DD} = 3.9 V, V- = 0.0 V	0 V battery charging: Permission		1.9	3.8	μA	V
			0 V battery charging: Inhibition		2.0	4.0		
Supply current in forced standby mode	I_{FSTB}	V_{DD} = V- = 3.9 V				0.04	μA	W
Standby current	$I_{STANDBY}$	V_{DD} = 1.9 V	Overdischarge: Auto release			0.20	μA	W
			Overdischarge: Latch			0.04		

*1 The test circuits for device evaluation. Refer to the section of *TEST CIRCUITS* for detail information.

All test parameters listed in Electrical Characteristics are done under Ta = 25°C only.

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Test Circuits

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

Nisshinbo Micro Devices Inc.
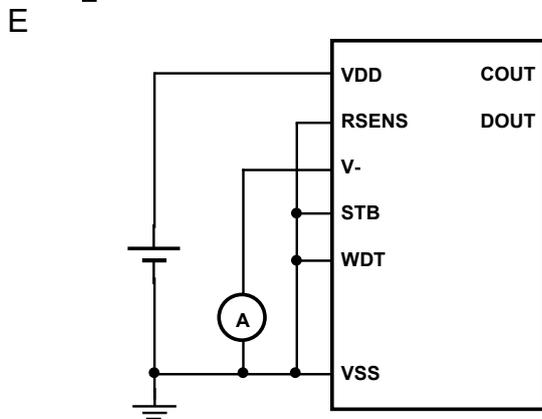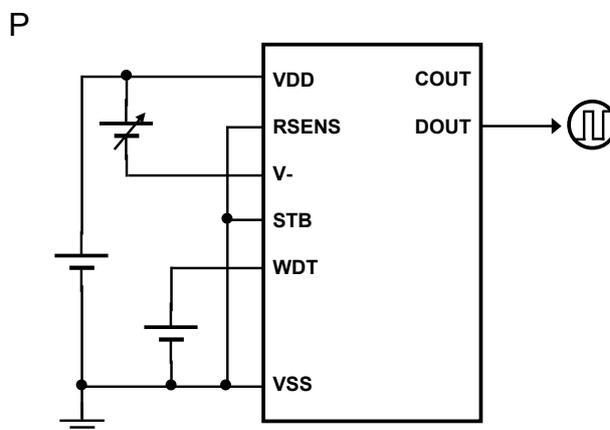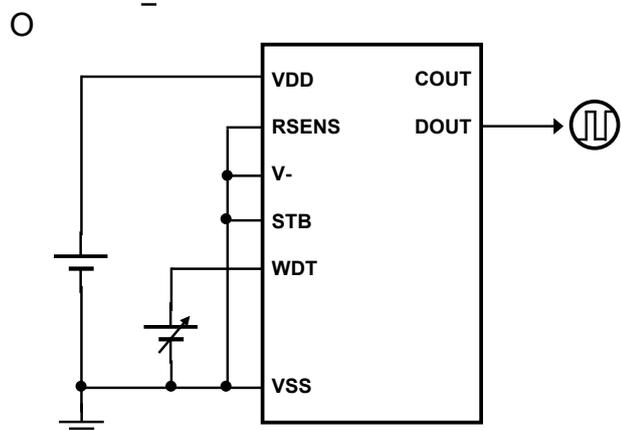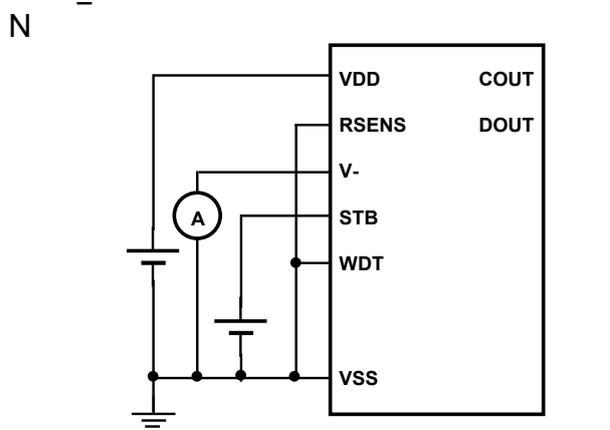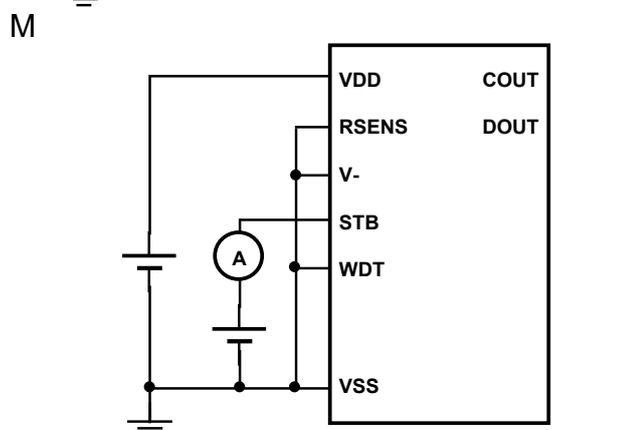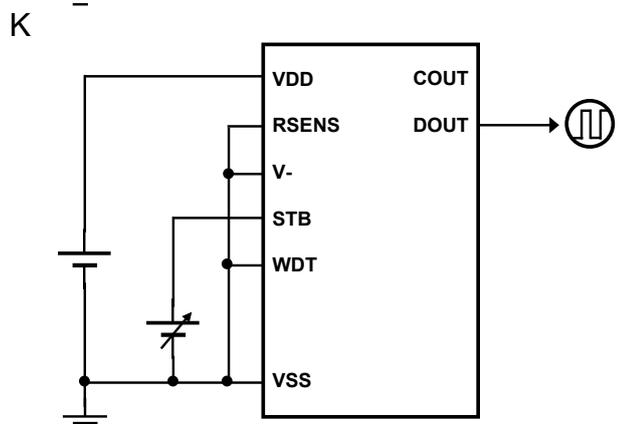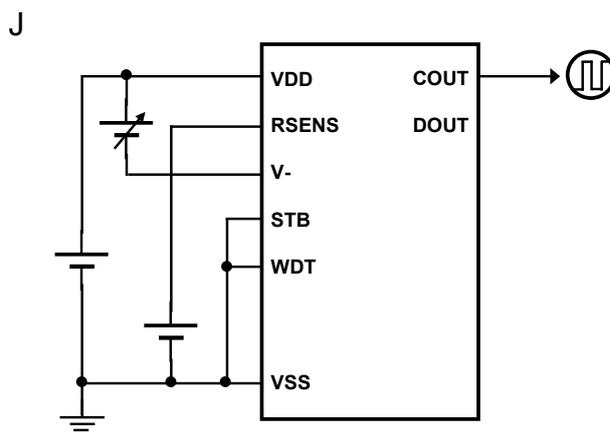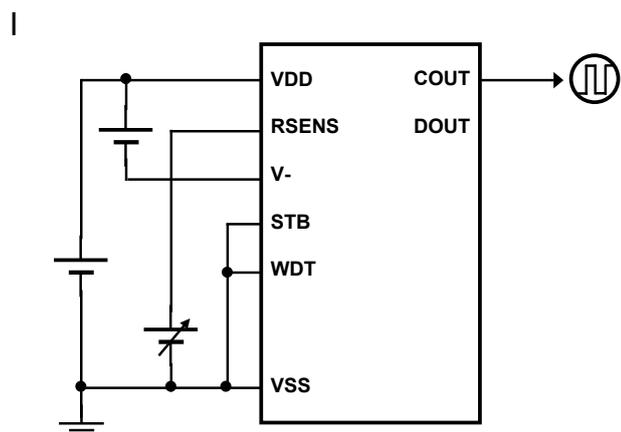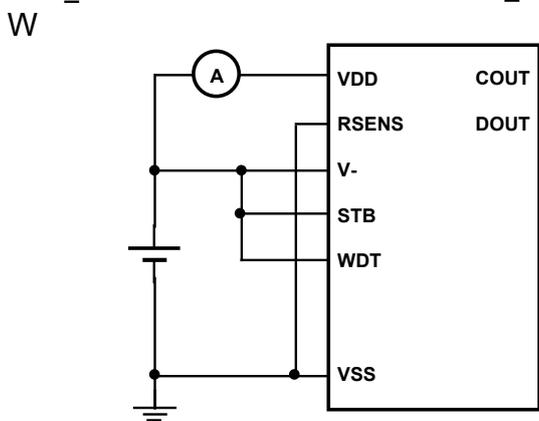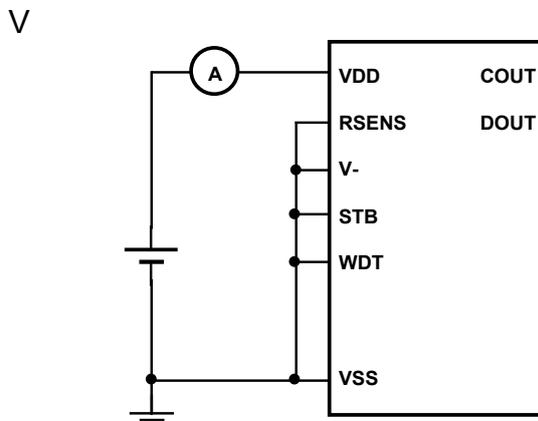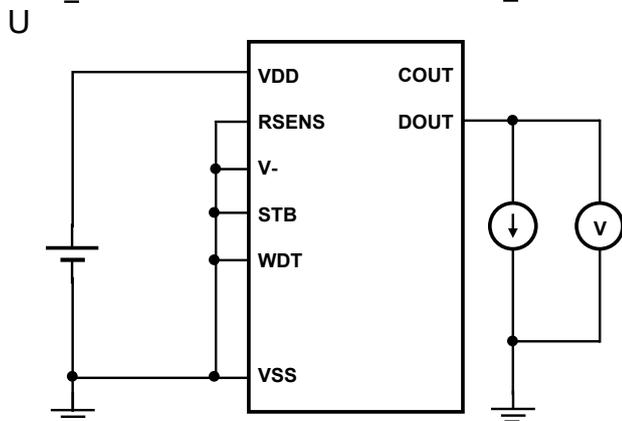
THEORY OF OPERATION

Overcharge Protection

When the overcharge detection delay time (t_{VDET1}) passes under the condition that the VDD pin voltage (V_{DD}) exceeds the overcharge detection voltage (V_{DET1}), this IC enters the over-charge state.

In this state, the COUT pin becomes Low, and the charge control FET is turned off to stop charging. The V- pin voltage (V-) increases by the Vf voltage (Vf) of the internal parasitic diode than the VSS pin voltage (V_{SS}) because the discharge current flows via the parasitic diode even when the charge control FET is off.

A release from the overcharge state must meet the following pin conditions and delay time according to the selected release type.

Type	Pin Conditions	Delay Time
Auto Release	V- < V_{REL4} and V_{DD} < V_{REL1} or V- > V_{REL4} and V_{DD} < V_{DET1}	t_{VREL1}
Latch	V- > V_{REL4} and V_{DD} < V_{DET1}	t_{VREL1}

Overdischarge Protection

When the overdischarge detection delay time (t_{VDET2}) passes under the condition that the VDD pin voltage (V_{DD}) falls below the over-discharge detection voltage (V_{DET2}), this IC enters the over-discharge state.

In this state, the DOUT pin becomes Low, and the discharge control FET is turned off to stop discharging. The V- pin voltage (V-) decreases by the Vf voltage (Vf) of the internal parasitic diode than the VSS pin voltage (V_{SS}) because the charge current flows via the parasitic diode even when the discharge control FET is off.

In addition, when V- is pulled up to V_{DD} level and exceeds the charger detection voltage (V_{CHGDET}), the IC enters the standby state. It results in reducing the standby current ($I_{STANDBY}$) to a minimum.

A release from the overdischarge state must meet the following pin conditions and delay time according to the selected release type.

Type	Pin Conditions	Delay Time
Auto Release	V- > V_{CHGDET} and V_{DD} > V_{REL2} or V- < V_{CHGDET} and V_{DD} > V_{DET2}	t_{VREL2}
Latch	V- < V_{CHGDET} and V_{DD} > V_{DET2}	t_{VREL2}

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Discharge Overcurrent Protection

To monitor a discharge current, this IC measures a voltage difference of the sense resistor (R_{SENS}) connected between the RSENS and the VSS pins to detect the current value.

This IC has two levels of the discharge overcurrent detection voltage 1/2 (V_{DET31} / V_{DET32}). When the discharge overcurrent detection delay time (t_{VDET31}) passes under the condition that the discharge current, which is converted through R_{SENS} for current-to-voltage conversion, exceeds V_{DET31}, this IC enters the discharge overcurrent state. In a case where V_{DET32} is enabled, this IC enters the discharge overcurrent state when the discharge overcurrent detection delay time (t_{VDET32}) passes under the condition exceeding V_{DET32}.

In this state, the DOUT pin becomes Low, and the discharge control FET is turned off to shut off the discharge current.

A release from the discharge overcurrent state must meet the following pin condition and delay time according to the selected release type.

Type	Pin Condition	Delay Time	Remarks
Auto Release 1	V- < V_{REL3} (Typ. V_{DD} × 0.800)	t_{VREL3}	V- is pulled down to the V_{SS} level inside the IC. [Note1] (R_{SHORT} = Typ.10kΩ)
Auto Release 2	V- < V_{REL3} (Typ. 0.700 V)	t_{VREL3}	V- is pulled down to the V_{SS} level inside the IC. [Note1] (R_{SHORT} = Typ.45kΩ)
Latch	V- < V_{REL3} (Typ. 0.700 V)	t_{VREL3}	V- is pulled up to the V_{DD} level inside the IC. [Note2]

Note1: It is possible to release the abnormal condition of the load connected to the battery pack. When the discharge overcurrent release delay time (t_{VREL3}) passes under the condition V- falls below V_{REL3}, this IC releases from the discharge overcurrent state. V- can be expressed by the following equation.

$$V\text{-} = V_{CELL} \times R_{SHORT} / (R_{SHORT} + R_{V\text{-}} + R_{LOAD})$$

V_{CELL} : Battery voltage
R_{SHORT} : Discharge overcurrent release resistance
$R_{V\text{-}}$: External resistor for V- pin
R_{LOAD} : Load resistance to a battery pack

Note2: When connecting a charger to pull V- down, this IC releases from the discharge overcurrent state.

Short-circuit Current Protection

To monitor a short-circuit current, this IC measures a voltage difference of the sense resistor (R_{SENS}) connected between the RSENS and the VSS pins to detect the current value. When the short-circuit current, which is converted through RSENS for current-to-voltage conversion, exceeds the short-circuit detection voltage1 (V_{SHORT1}), this IC enters the short-circuit state. But it is possible for this IC to avoid its state when the short-circuit current falls below V_{SHORT1} within the short-circuit detection delay time (t_{SHORT}).

In this state, the DOUT pin becomes Low, and the discharge control FET is turned off to shut off the short-circuit current.

A release from the short-circuit state must meet the same condition and delay time as the discharge overcurrent protection.

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Charge Overcurrent Protection

To monitor a charge current, this IC measures a voltage difference of the sense resistor (R_{SENS}) connected between the RSENS and the VSS pins to detect the current value. When the charge overcurrent detection delay time (t_{VDET4}) passes under the condition that the charge current, which is converted through RSENS for current-to-voltage conversion, falls below the charge overcurrent detection voltage (V_{DET4}), this IC enters the charge overcurrent state.

In this state, the COUT pin becomes Low, and the charge control FET is turned off to shut off the charge current.

A release from the charge overcurrent state must meet the following pin condition and delay time according to the selected release type.

Type	Pin Condition	Delay Time	Remarks
Auto Release	V- > V_{REL4}	t_{VREL4}	V- is pulled up to the V_{DD} level inside the IC. [Note]

Note: By disconnecting the charger, this IC releases from the charge overcurrent state.

0 V Battery Charging

This IC has the selectable charging function for the battery discharged to 0 V.

0 V Battery Charge Function "Permission"

This function allows to charge to the 0 V battery by connecting the charger with the minimum charging voltage (V_{STCHG}) and more.

0 V Battery Charge Function "Inhibition"

This function inhibits to charge to the battery with the 0 V-battery charging inhibition voltage (V_{NOCHG}) or less even when connecting the charger.

Forced-standby Function

When the forced standby detection delay time (t_{STBD}) passes under the condition that the STB pin voltage (V_{STB}) exceeds the forced standby detection voltage (V_{STBD}), this IC enters the forced standby detected state.

In this state, the IC turns off the charge and the discharge control FETs and the V- pin is pulled up to the VDD level by an internal resistor, here the V- pin pullup resistance is R_{V-2}.

After that, the IC enters the forced standby state when V- exceeds the charger detection voltage (V_{CHGDET}). It results in reducing the supply current (I_{FSTB}) to a minimum.

A release from the forced standby state must meet the following pin condition and delay time according to the selected release type.

Type	Pin Condition	Delay Time	Remarks
Latch	V- < V_{CHGDET}	t_{STBR}	V- is required to exceed V_{SHORT2} once for the release. The IC should not enter the forced standby state under connecting the charger.

Watchdog Timer Function

During the watchdog timeout period (tWD), the timeout counter is reset when the WDT pin receives an edge signal. Conversely, the watchdog timer is reset state when not receive it.
In this state, the IC turns off the charge and the discharge control FETs.

A release from the forced reset state must meet the following pin condition and delay time according to the selected release type.

Type	Pin Condition	Delay Time	Remarks
Auto release	-	t_{WR}	Immediately after forced reset detected, watchdog timer reset release delay time (t_{WR}) counting start.
V- rising	V- > V_{SHORT2}	t_{WR}	After the system power is depleted, watchdog timer reset release delay time (t_{WR}) counting start.

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Timing Chart

Overcharge

Overcharge (Auto Release) Timing Chart

Overcharge (Latch) Timing Chart

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Overdischarge

Overdischarge (Auto Release) Timing Chart

Overdischarge (Latch) Timing Chart

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Discharge Overcurrent

Discharge Overcurrent (Auto Release) Timing Chart
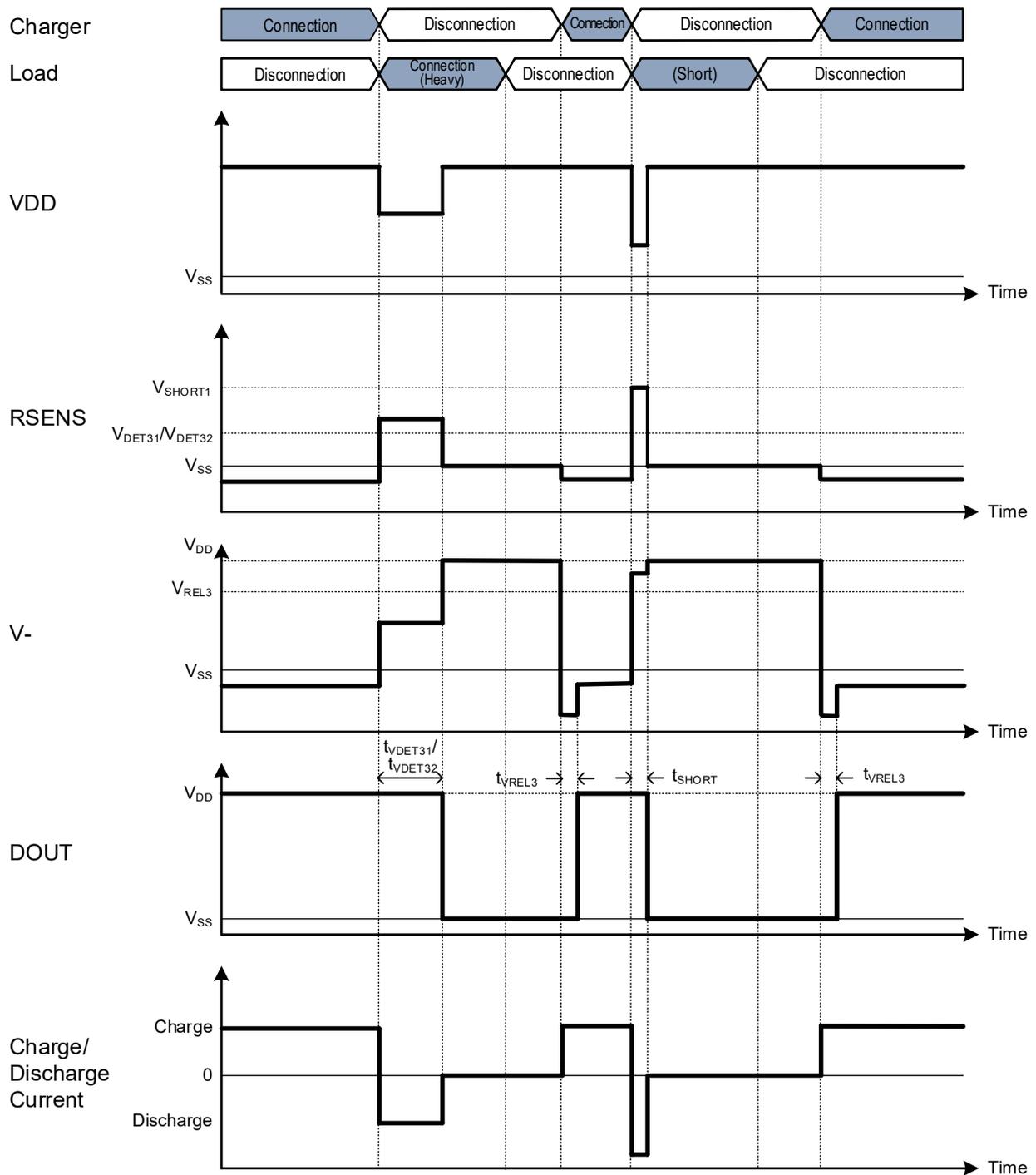
Discharge Overcurrent (Latch) Timing Chart

Charge Overcurrent

| Charger | Disconnection | Connection | Disconnection |
| Load | Connection | Disconnection | Connection |

VDD

RSENS

V-

COUT

Charge/ Discharge Current

t_{VDET4}

t_{VREL4}

V_{SS}

V_{DET4}

V_{REL4}

V_{SS}

V_{DD}

(V-)
V_{SS}

Charge

0

Discharge
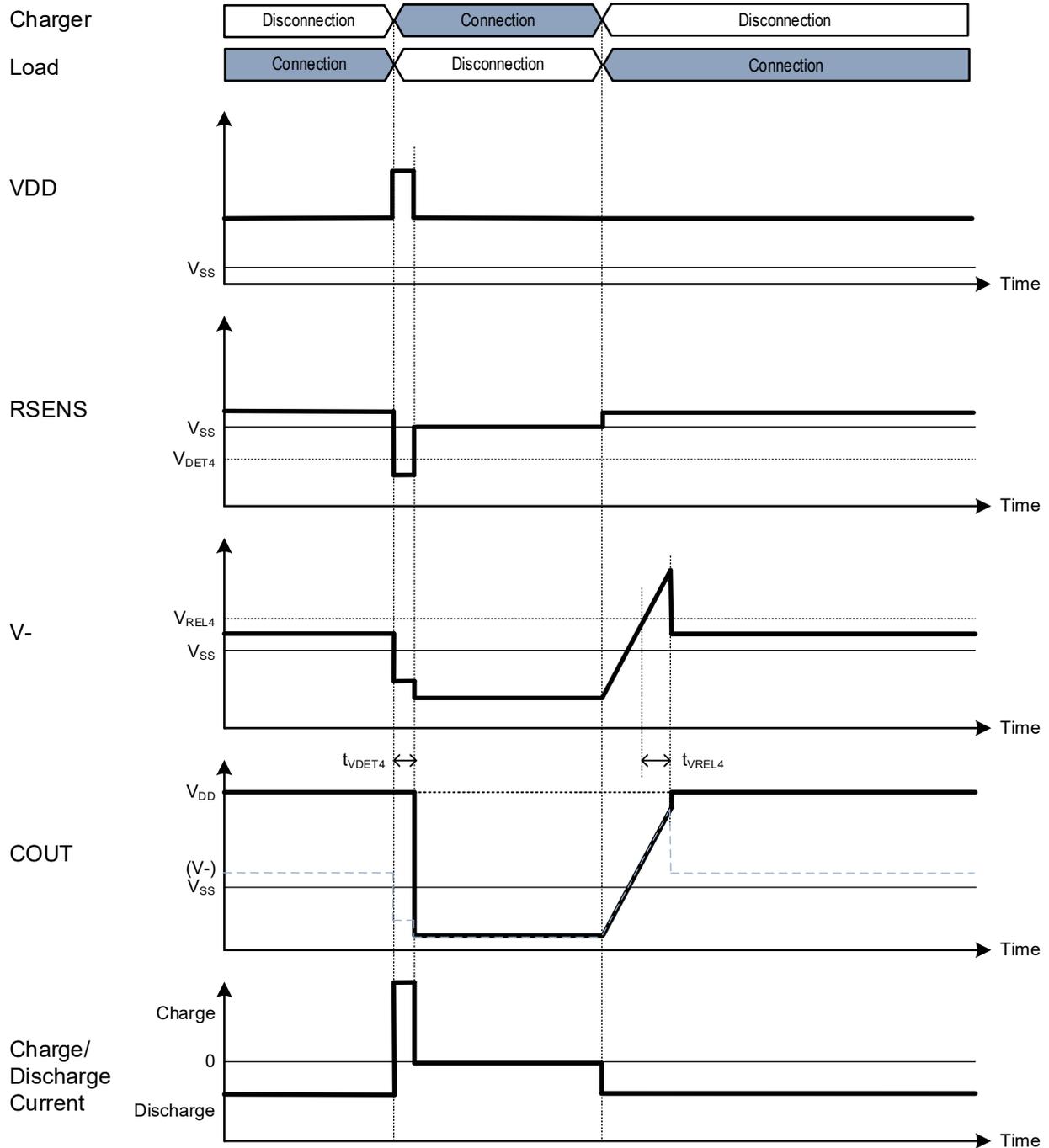
Time

Charge Overcurrent Timing Chart

Watchdog Timer

Charger | Disconnection

Load | Connection

WDT

V_{WDT}
V_{SS}
Charger Level
t_{WD} t_{WR} t_{WD} t_{WR}
Time

V-

V_{DD}
V_{SS}
Charger Level
Rising voltage
$= I_{SYS} \times t_{WR} \times C_{SYS}$ [1]
Time

DOUT

V_{DD}
V_{SS}
Time

COUT

V_{DD}
V- / V_{SS}
Time

Supply Current

I_{DD}
I_{STB}
0
Time
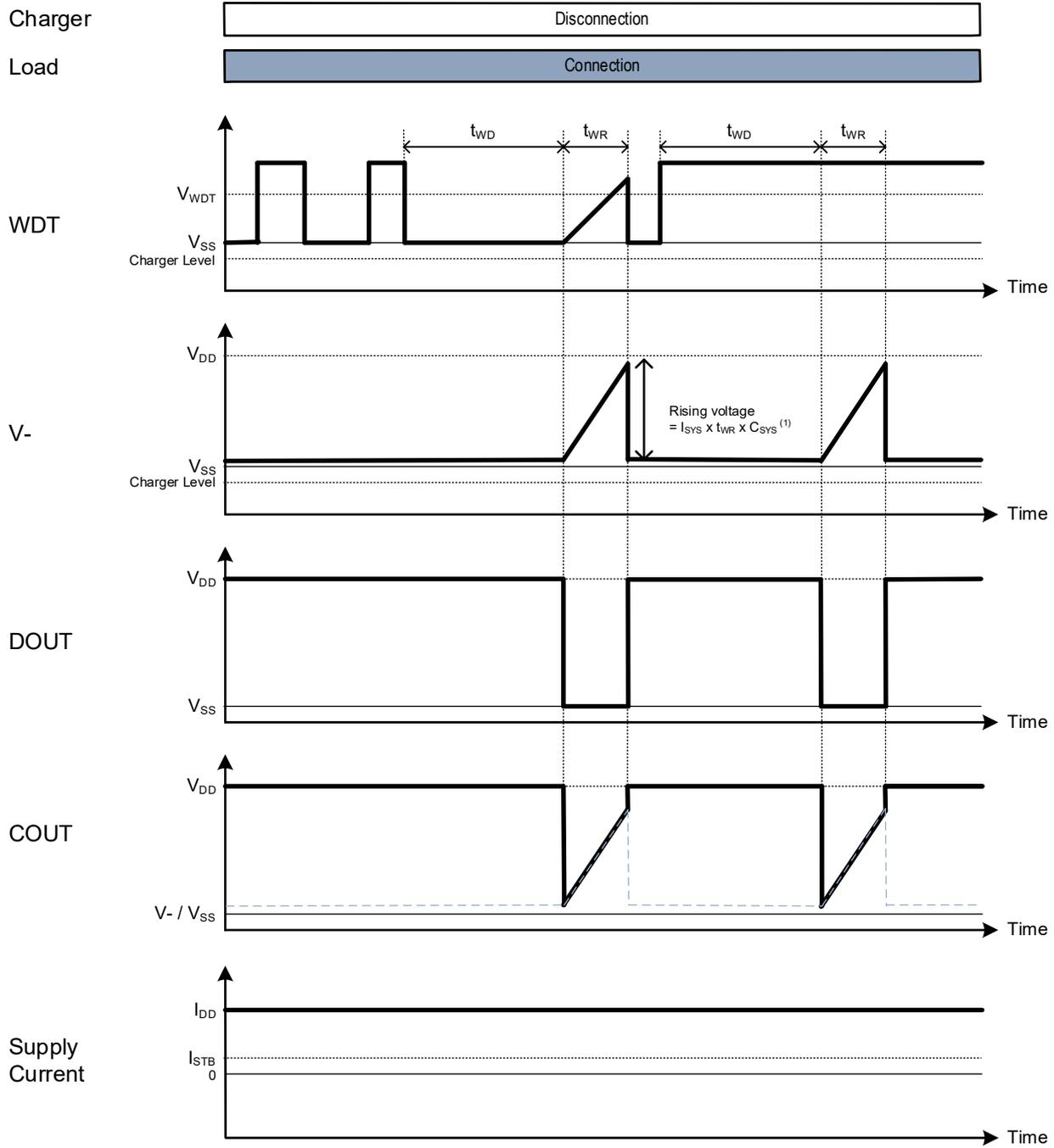
Watch Dog Timer (Auto release) Timing Chart

[1] I_{SYS}, C_{SYS} : Refer to the chapter "*TYPICAL APPLICATION CIRCUIT*".
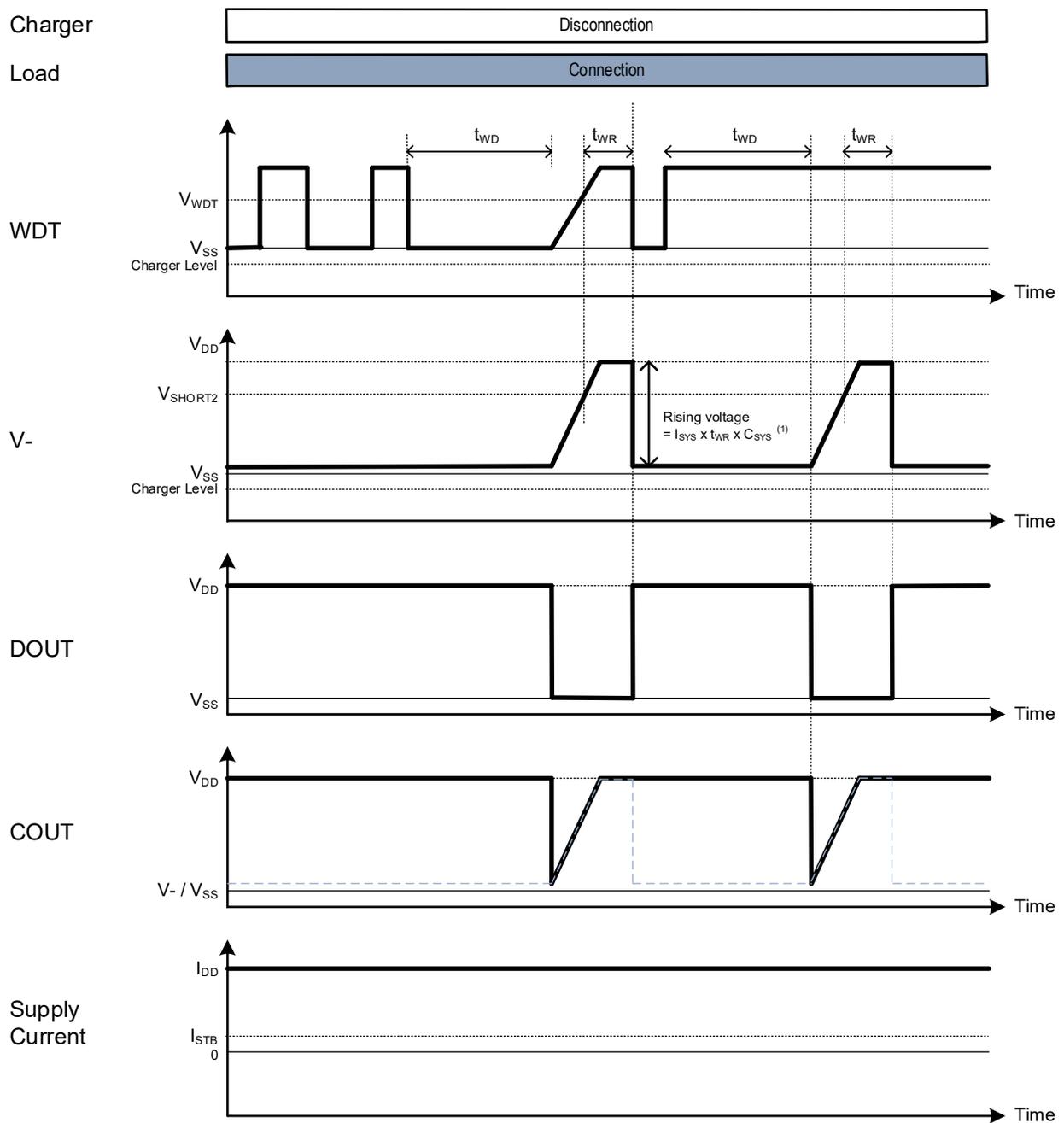
Watch Dog Timer (V- rising) Timing Chart

[1] I_{SYS}, C_{SYS} : Refer to the chapter "*TYPICAL APPLICATION CIRCUIT*".

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Forced Standby Mode
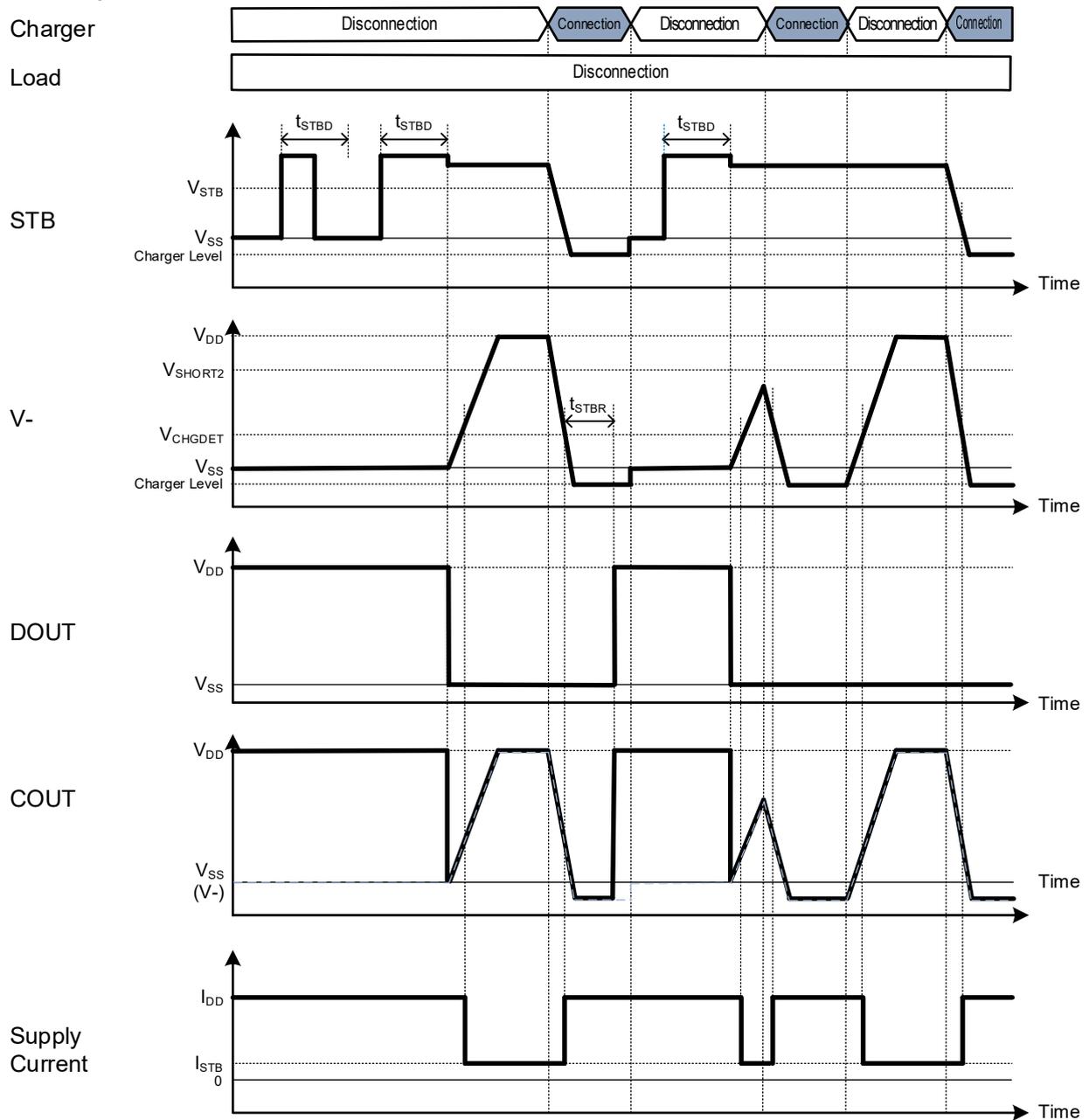
Forced Standby Mode Timing Chart

TYPICAL APPLICATION CIRCUIT
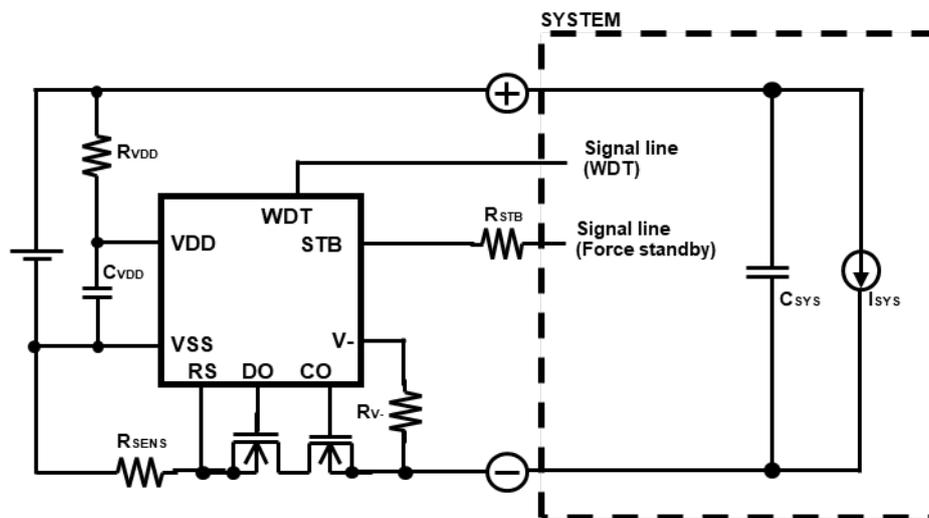
NB7141ZA Typical Application Circuit

External Components

Symbol	Min.	Typ.	Max.
Resistor			
R_{VDD} [*1]	-	330Ω	1kΩ
R_{V-} [*1]	-	1.0kΩ	1.3kΩ
R_{SENS}	-	1.5mΩ	-
R_{STB}	-	1.0kΩ	10kΩ
Capacitor			
C_{VDD}	0.01μF	0.10μF	1.00μF

[*1] The total resistance of R_{VDD} and R_{V-} must be 1kΩ or more.

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Technical Notes Related to External Components

● The voltage fluctuation is stabilized with R_{VDD} and C_{VDD}. If a R_{VDD} is too large, the detection voltage rises   by the conduction current at detection. To stabilize the operation, it is recommended to use a resistor of 1kΩ or less for R_{VDD} and a capacitor of 0.01 μF to 1.00 μF for C_{VDD}.

● R_{VDD} and R_{V-} serve as a current limit resistor when the battery pack is charged with reversed polarity, or a voltage of the connected charger is more than the absolute maximum rating. When using a small resistor for R_{VDD} and R_{V-}, the device's power dissipation might be exceeded. Therefore, a total of R_{VDD} and R_{V-} must be 1kΩ or more. When using a large resistor for R_{V-}, the charger might not be released by re-connecting to the battery pack after the over-discharge detection. Therefore, R_{V-} must be 1.3kΩ or less. Production variation and temperature properties are included in the value. R_{SENS} is a resistor for sensing an overcurrent. If the resistance value is too large, power loss becomes also large. By the overcurrent, if the R_{SENS} is not appropriate, the power loss may be beyond the power dissipation of R_{SENS}. Choose an appropriate R_{SENS} according to the cell specification.

● The typical application circuit diagrams are just examples. This circuit performance largely depends on the PCB layout and external components. In the actual application, fully evaluation is necessary.

● If the positive terminal and the negative terminal of the battery pack are short even though the device has the short protection circuit, a large current may flow through the FET during the delay time until detecting the short circuit. Therefore, select an appropriate FET with large enough current capacitance to endure the large current during the delay time.

Selection of External Sense Resistor and MOSFET

Short mode is detected by the current base or the relation between V_{DD} at short and total on resistance of external MOSFETs for C_{OUT} and D_{OUT}. When a short circuit detection is required with the current determined by V_{SHORT1}, V_{SHORT2}, and R_{SENS}, the next formula must be true, otherwise, the short current limit becomes $(V_{SHORT2}) / (R_{SENS} + R_{SS}(on))$.

$$\frac{V_{SHORT2}}{R_{SENS}+R_{SS}(on)} \geq \frac{V_{SHORT1}}{R_{SENS}}$$

V_{SHORT1} = Threshold value of detecting short circuit using R_{SENS} terminal [V]
V_{SHORT2} = Threshold value of detecting short circuit using V- terminal [V]
R_{SENS} = External current sense resistance [Ω]
R_{SS} (on) = external MOSFETs' total ON resistance [Ω]

In the short mode, a short current is determined by the relation between R_{SENS} and V_{SHORT1} value.

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TECHNICAL NOTES

A peripheral component or the device mounted on PCB should not exceed a rated voltage, a rated current or a rated power. When designing a peripheral circuit, please be fully aware of the following points.

- Please evaluate the product at the PCB level before use, as some symptoms may remain that cannot be confirmed by the evaluation at the IC level.
- When using any coating or underfill to improve moisture resistance or joining strength, evaluate them adequately before using. In certain materials or coating conditions, corrosion by contained constituents, current leakage by moisture absorption, crack and delamination by physical stress can happen. If the curing temperature of the coating material or underfill material exceeds the absolute maximum rating, the electrical characteristics of this product may change.
- When performing X-ray inspection in mass production process and evaluation build stage such as the product functions and characteristics confirmation, please confirm X-ray irradiation does not exceed 1.5Gy (absorbed dose for air).

REVISION HISTORY

Date	Version	Changes
June 20, 2022	1.00	First public release
July 22, 2022	1.10	Corrected mistakes in writing.
August 1, 2022	1.20	Added Electrostatic Discharge (ESD) ratings.
September 22, 2022	1.30	Updated timing diagrams in the timing chart section.
November 7, 2022	1.40	Deleted marking information from ORDER INFORMATION and PKG INFORMATION and merge them as Marking Specification. Updated timing diagrams in the timing chart section.

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		Set Voltage [V] / Delay Time [ms]															Optional Function				
		V_{DET1}/t_{VDET1}	V_{REL1}/t_{VRET1}	V_{DET2}/t_{VDET2}	V_{REL2}/t_{VREL2}	V_{DET31}/t_{VDET31}	V_{DET32}/t_{VDET32}	t_{VREL3}	V_{DET4}/t_{VDET4}	t_{VREL4}	V_{SHORT}/t_{SHORT}	V_{NOCHG}	V_{STBD}/t_{STBD}	t_{STBR}	V_{WDT}/t_{WD}	t_{WIR}	Unit	Overcharge Release	Overdischarge Release [*1]	Discharge Overcurrent Release	Discharge Overcurrent Detection2 [*2]	0V Battery Charging [*3]
NB7141ZA**205EH**E2S		4.525	-	3.100	-	0.0110	-	-	-0.0400	-	0.046	2.00	1.20	-	0.65	-	V	Latch	Latch	Auto2	No	No
		1024	16.0	128	1.05	4096	-	9.0	10.0	4.0	0.28	-	300	33	25.6[s]	1024	ms					
NB7141ZA**205EM**E2S		4.525	-	3.100	-	0.0110	-	-	-0.0400	-	0.046	2.00	0.65	-	0.65	-	V	Latch	Latch	Auto1	No	No
		1024	16.0	128	1.05	4096	-	9.0	10.0	4.0	0.28	-	300	33	25.6[s]	1024	ms					
NB7141ZA**205EN**E2S		4.525	-	3.100	-	0.0110	-	-	-0.0400	-	0.046	2.00	0.65	-	0.65	-	V	Latch	Latch	Auto1	No	Yes
		1024	16.0	128	1.05	4096	-	9.0	10.0	4.0	0.28	-	300	33	25.6[s]	1024	ms					
NB7141ZA**206HR**E2S		4.200	4.000	2.100	2.300	0.0500	-	-	-0.0170	-	0.060	1.00	0.65	-	0.65	-	V	Auto	Auto	Auto1	No	No
		1024	16.0	32	1.05	1024	-	9.0	17.0	4.0	0.28	-	50	4.5	1.024[s]	200	ms					

[*1] Overdischarge Release Conditions,

Auto (Auto Release): Cell voltage > V_{REL2}

Latch : Cell voltage > VDET2 under charger connection

[*2] Yes : Available   No: Unavailable

[*3] Yes : Permission   No: Inhibition

N B 7 1 4 1 Z A x x x x x x E 2 S

— Grade (Consumer)

— Orientation in taping pocket (E2)

— Series Name

— Package Type (ZA:WLCSP)

PKG: WLCSP-8-P10

A2   D2

① ② ③ ④

A1   D1
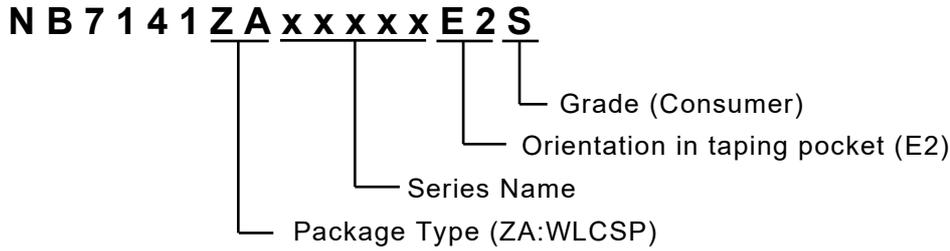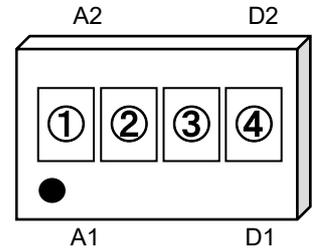
①② : Product code (See below)
③④ : Lot No.(series)

NOTICE
There can be variation in the marking when different AOI (Automated Optical Inspection) equipment is used. In the case of recognizing the marking characteristic with AOI, please contact our sales or distributor before attempting to use AOI.

Product Name	① ②
NB7141ZA205EH	U 0
NB7141ZA205EM	U 1
NB7141ZA205EN	U 2
NB7141ZA206HR	U 3

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WLCSP-8-P10

■ **PACKAGE DIMENSIONS**

UNIT: mm
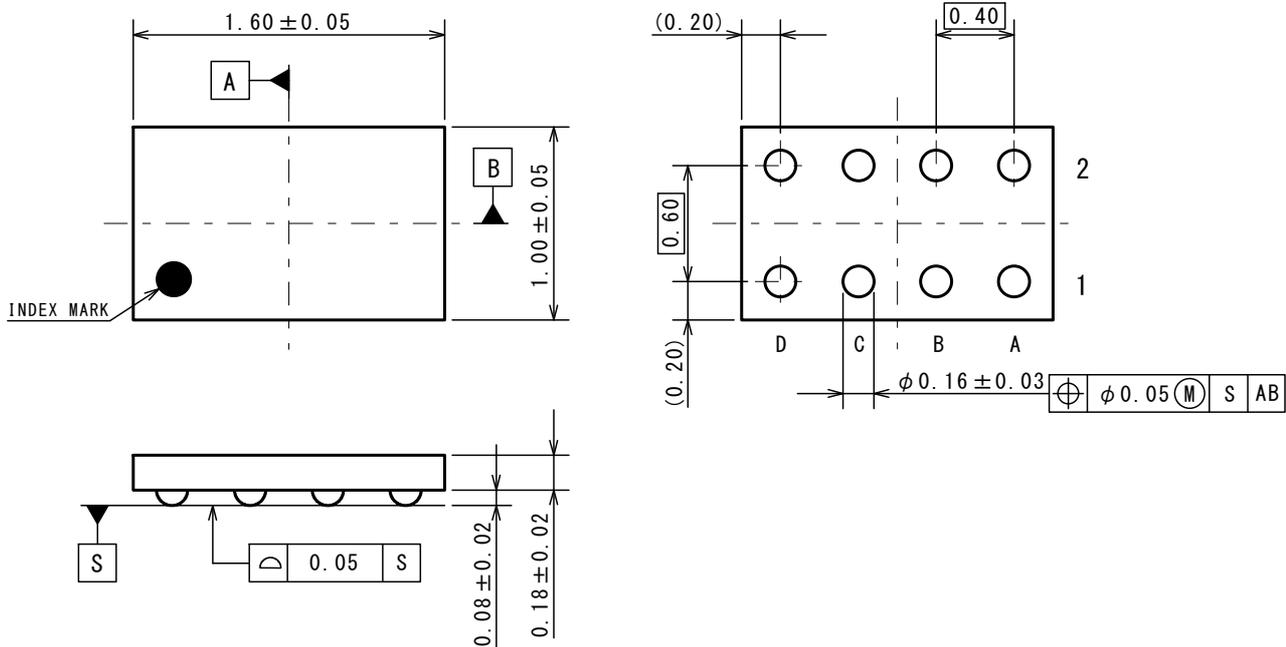
■ **EXAMPLE OF SOLDER PADS DIMENSIONS**
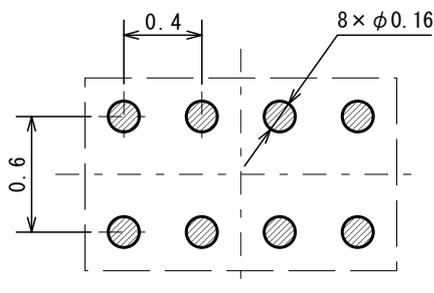
Recommended Land Pattern
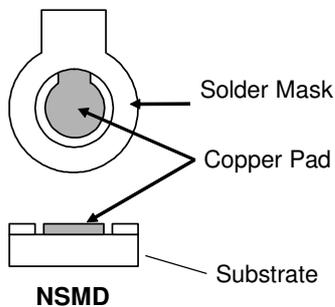
NSMD

NSMD Pad Definition		
Pad definition	Copper Pad	Solder Mask Opening
NSMD (Non-Solder Mask defined)	0.16mm	MIN. 0.26mm

*) Pad Layout and size can modify by customers material, equipment and method.
*) Please adjust pad layout according to your conditions.
*) Recommended Stencil Aperture Size: φ0.26mm

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WLCSP-8-P10

■ **PACKING SPEC**

UNIT: mm

(1) Taping dimensions / Insert direction

Carrier tape material: PC
Cover tape material: PE

(2) Taping state

Feed direction

Sealing with covering tape

Trailer part	Devices	Leader part
more than 160mm	5000pcs/reel	more than 550mm

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WLCSP-8-P10   PI-WLCSP-8-P10-E-B

(3) Reel dimensions

Reel material: PS

11.4 ± 1.0

2 ± 0.5

21 ± 0.8   13 ± 0.2

60^{+1}_{0} 180^{0}_{-3}

$9^{+1.0}_{-0.3}$
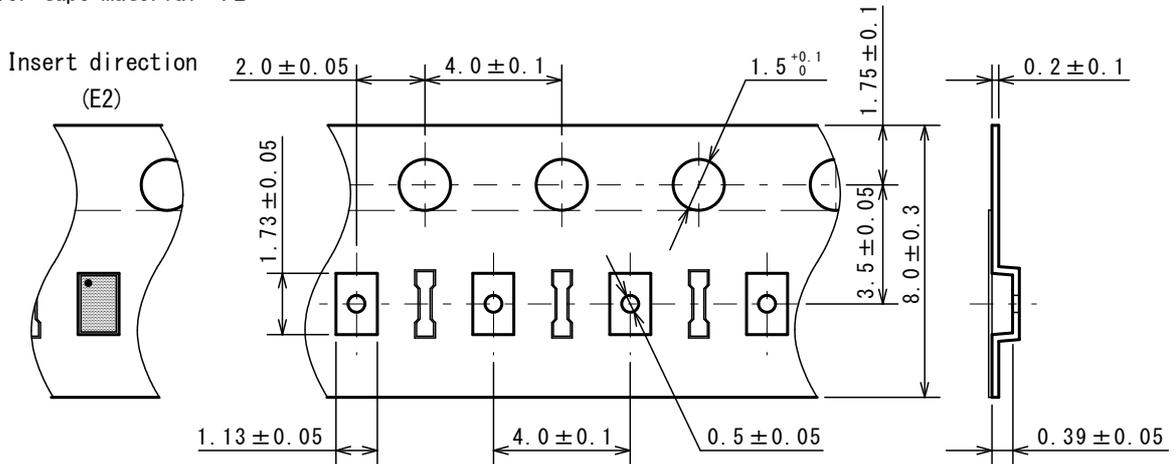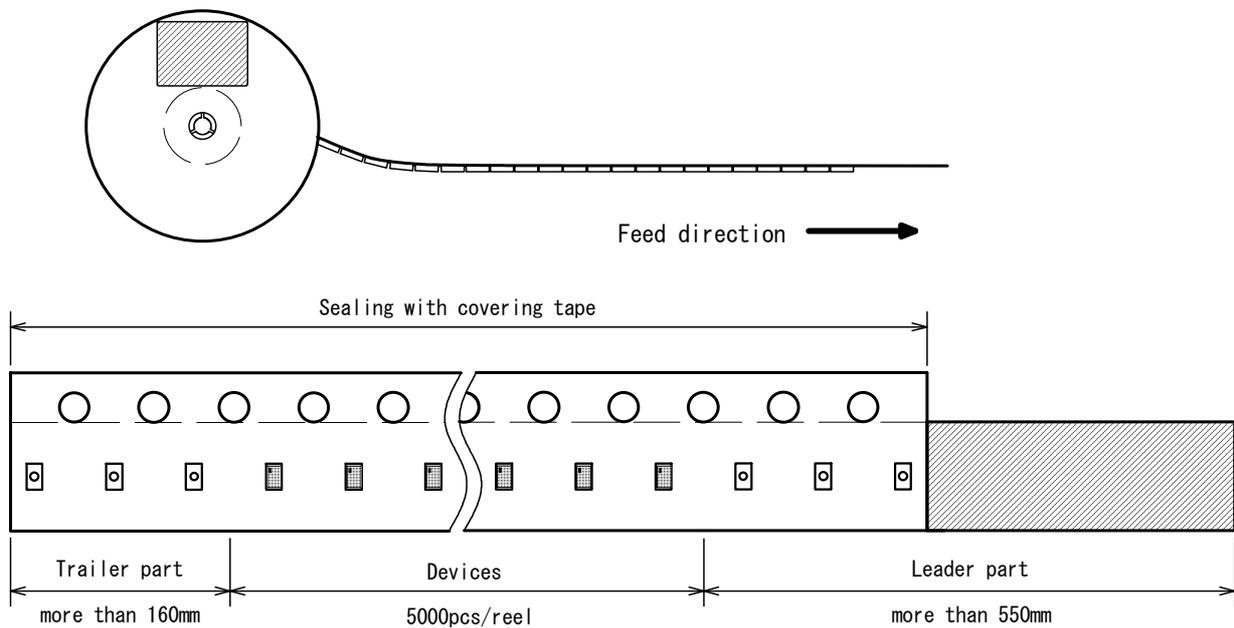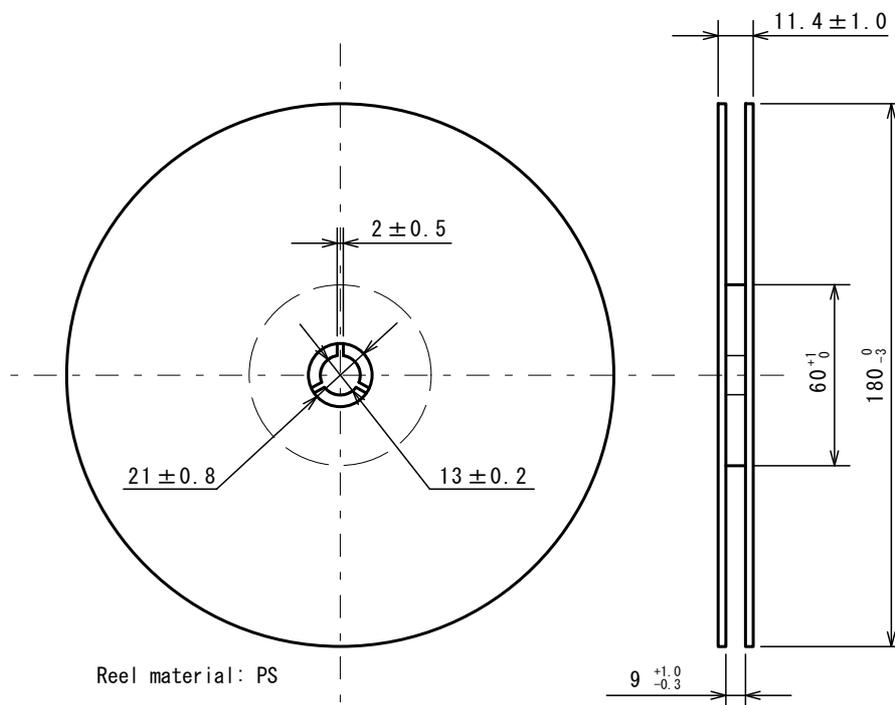
(4) Peeling strength

Peeling strength of cover tape
・Peeling angle   165 to 180° degrees to the taped surface.
・Peeling speed   300mm/min
・Peeling strength   0.1 to 1.0N

165 to 180°

Cover tape

Direction to pull

Feed direction

Carrier tape

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WLCSP-8-P10

(5) Packing state

<Label> Prodcut name, Quantity, Lot No, Mark

1reel

Box size : 185×185×20

MAX: 5reel

Box size : 185×185×80
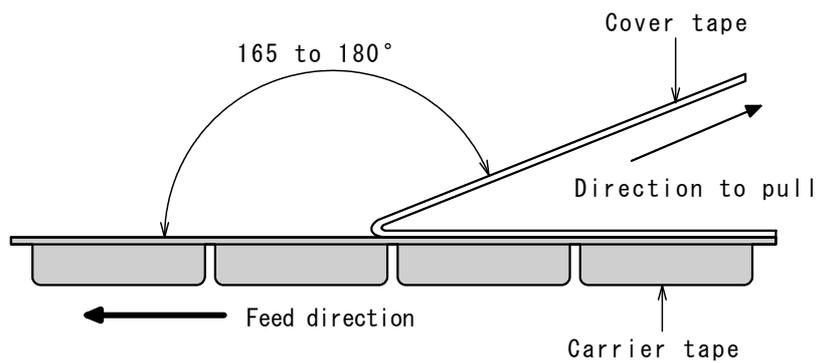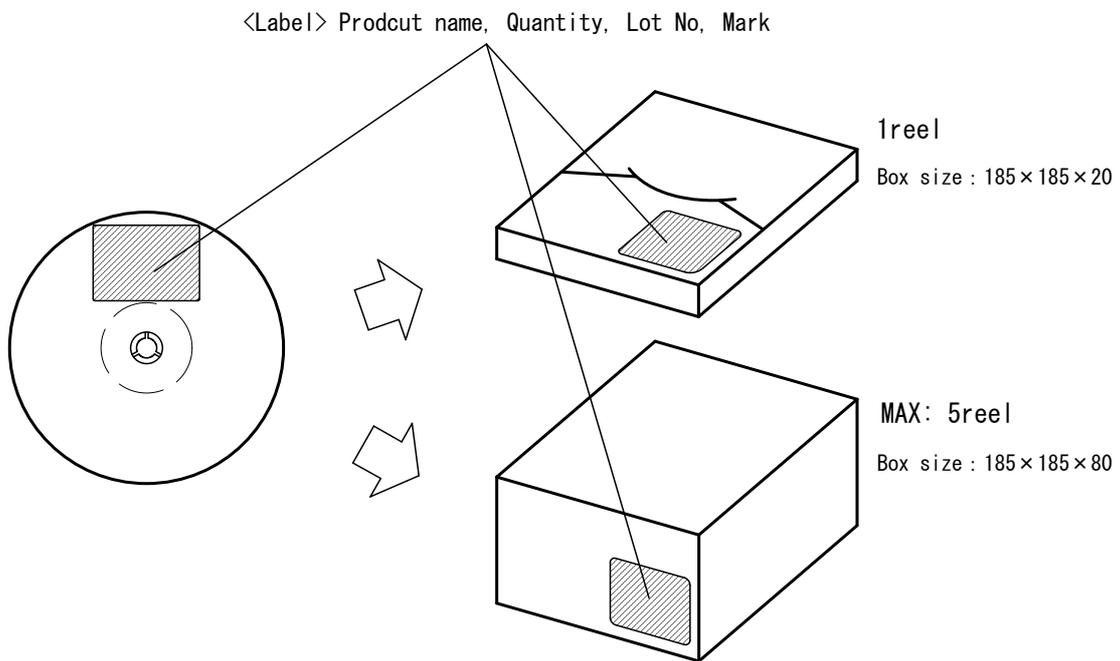
■ **HEAT-RESISTANCE PROFILES**

3℃/s MAX.

255℃

260℃

30s MAX.

6℃/s MAX.

217℃

200℃

150℃

60-150s

60-120s

Package Surface Temperature(℃)

Time(s)

Reflow profile

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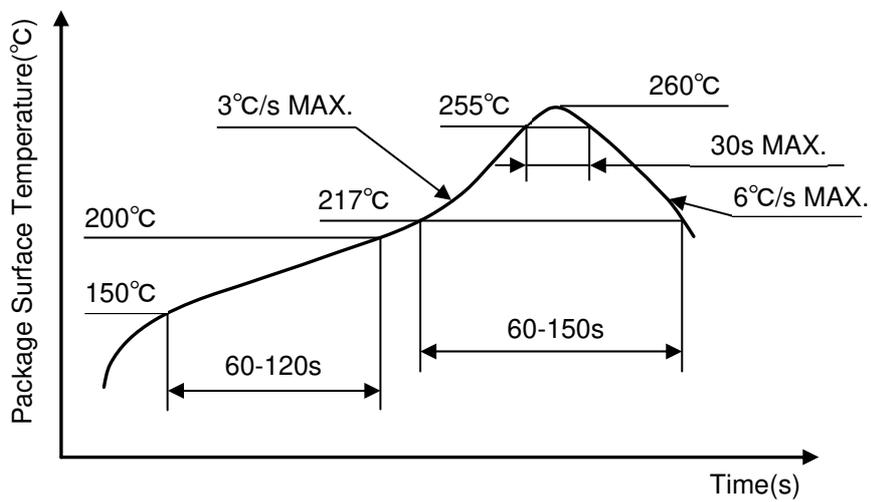
Visual Inspection Criteria

No.	Inspection Items	Inspection Criteria	Figures
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/ White LED/ Viewed from vertical direction)	
8	Scratch	To reject unreadable marking character by scratch. (Microscope: X15/ White LED/ Viewed from vertical direction)	
9	Stain and Foreign material	To reject unreadable marking character by stain and foreign material. (Microscope: X15/ White LED/ Viewed from vertical direction)	

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