S-19192 Series

AUTOMOTIVE, 105°C OPERATION, BATTERY MONITORING IC FOR 3-SERIAL TO 6-SERIAL CELL PACK

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The S-19192 Series is a monitoring IC for automotive rechargeable batteries, which includes high-accuracy voltage detection circuits and delay circuits. Switching control for 3-serial to 6-serial cell is possible by inputting voltage to the SEL1 pin and the SEL2 pin.
In addition, the S-19192 Series can perform a self-test to confirm overcharge and overdischarge detection operations.

Caution This product can be used in vehicle equipment and in-vehicle equipment. Before using the product for these purposes, it is imperative to contact our sales representatives.

■ Features

- High-accuracy voltage detection circuit for each cell
  - Overcharge detection voltage n (n = 1 to 6): 2.500 V to 4.500 V (25 mV step) Accuracy ±20 mV (Ta = +25°C)
    Accuracy ±30 mV (Ta = –5°C to +55°C)
  - Overcharge release voltage n (n = 1 to 6): 2.300 V to 4.500 V[*1] Accuracy ±50 mV
  - Overdischarge detection voltage n (n = 1 to 6): 1.500 V to 3.000 V (100 mV step)[*2, *3] Accuracy ±80 mV
  - Overdischarge release voltage n (n = 1 to 6): 1.500 V to 3.300 V[*4] Accuracy ±100 mV
- Self-test results to confirm overcharge and overdischarge detection operations can be output from OUT2 pin.
  - Delay time shortening during self-test: Available, unavailable
  - Self-test result output latch: Available, unavailable
- Each delay time is settable by an internal circuit only (External capacitors are not necessary).
  - Detection delay time: 32 ms, 64 ms, 128 ms, 256 ms
  - Release delay time: 2.0 ms, 4.0 ms, 8.0 ms, 16.0 ms
- Switching control for 3-serial to 6-serial cell is possible by inputting voltage to the SEL1 pin and the SEL2 pin.
- Two detection signal types:
  - Common: OUT1 pin: Overcharge and overdischarge detection signal
  - Separate: OUT1 pin: Overcharge detection signal
    OUT2 pin: Overdischarge detection signal
- Output form: CMOS output, Nch open-drain output
- Output logic: Active "H", active "L"
- High-withstand voltage: Absolute maximum rating 28.0 V
- Wide operation voltage range: 6.0 V to 28.0 V
- Wide operation temperature range: Ta = –40°C to +105°C
- Low current consumption
  - During operation: 18 µA max. (Ta = +25°C)
- Lead-free (Sn 100%), halogen-free
- AEC-Q100 qualified[*5]
- This IC has been developed for the battery management system in accordance with ISO 26262.
  ABLIC Inc. can provide a safety manual for this IC.[*5, *6]

***1.** Overcharge release voltage = Overcharge detection voltage – Overcharge hysteresis voltage
(Overcharge hysteresis voltage n (n = 1 to 6) is selectable from 0 V to 400 mV in 50 mV step.)

***2.** Set the voltage difference between the overcharge detection voltage and overdischarge detection voltage to 2.5 V or lower.
Set the voltage ratio so that the following formula is satisfied:
Overcharge detection voltage × 0.7 > Overdischarge detection voltage

***3.** When the S-19192 Series is used for monitoring a 3-serial-cell battery, set the overdischarge detection voltage n (n = 1 to 6) to 2.0 V or higher.

***4.** Overdischarge release voltage = Overdischarge detection voltage + Overdischarge hysteresis voltage
(Overdischarge hysteresis voltage n (n = 1 to 6) is selectable from 0 V to 0.7 V in 100 mV step.)

***5.** Contact our sales representatives for details.

***6.** A Non-Disclosure Agreement is necessary when providing the documents.

■ Application

- Automotive rechargeable battery pack (EV, HEV, PHEV)

■ Package

- HTSSOP-16

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■ Block Diagram

1. CMOS output

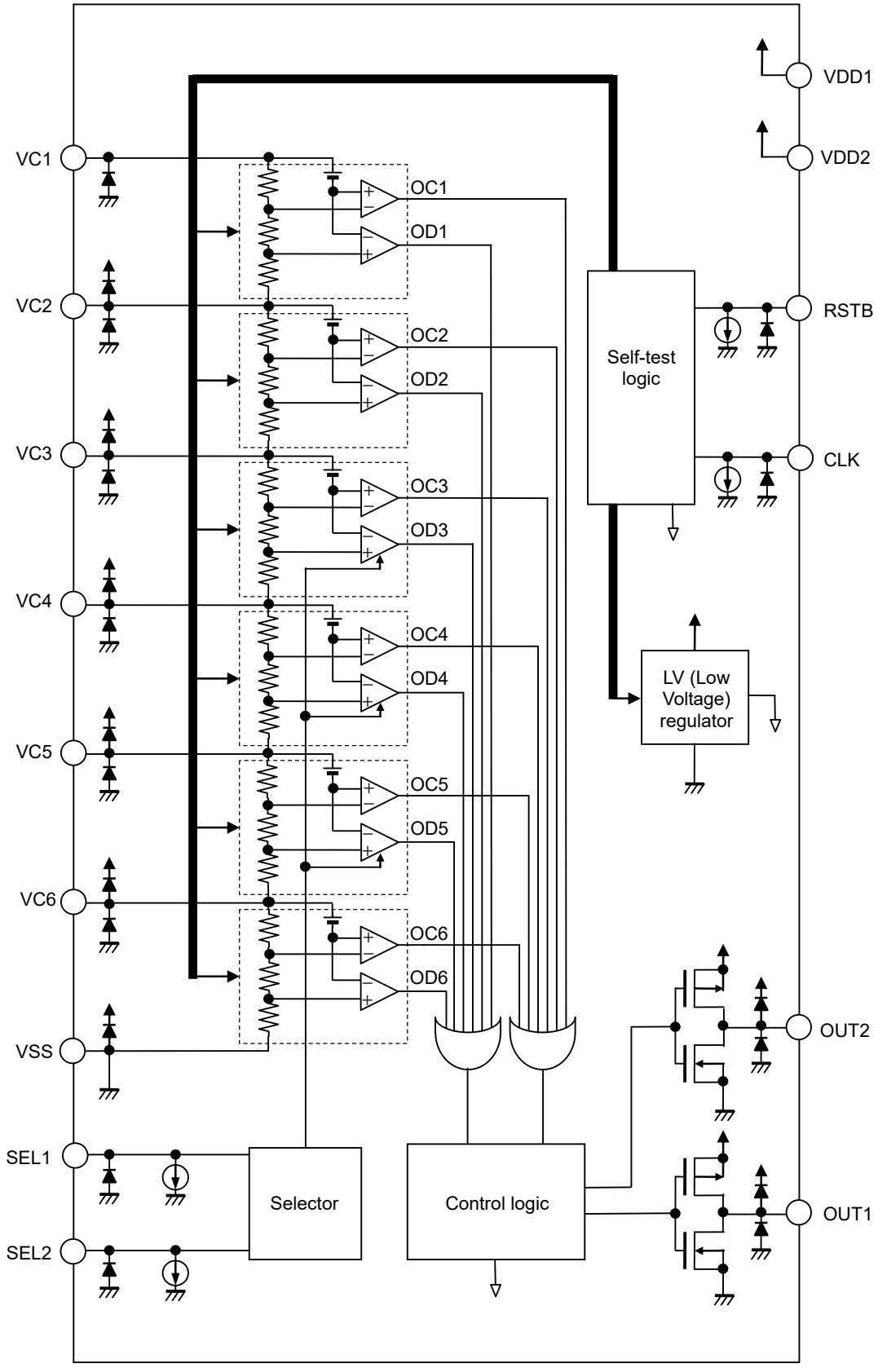


Figure 1

Remark The diodes in the figure are parasitic diodes.

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2. Nch open-drain output

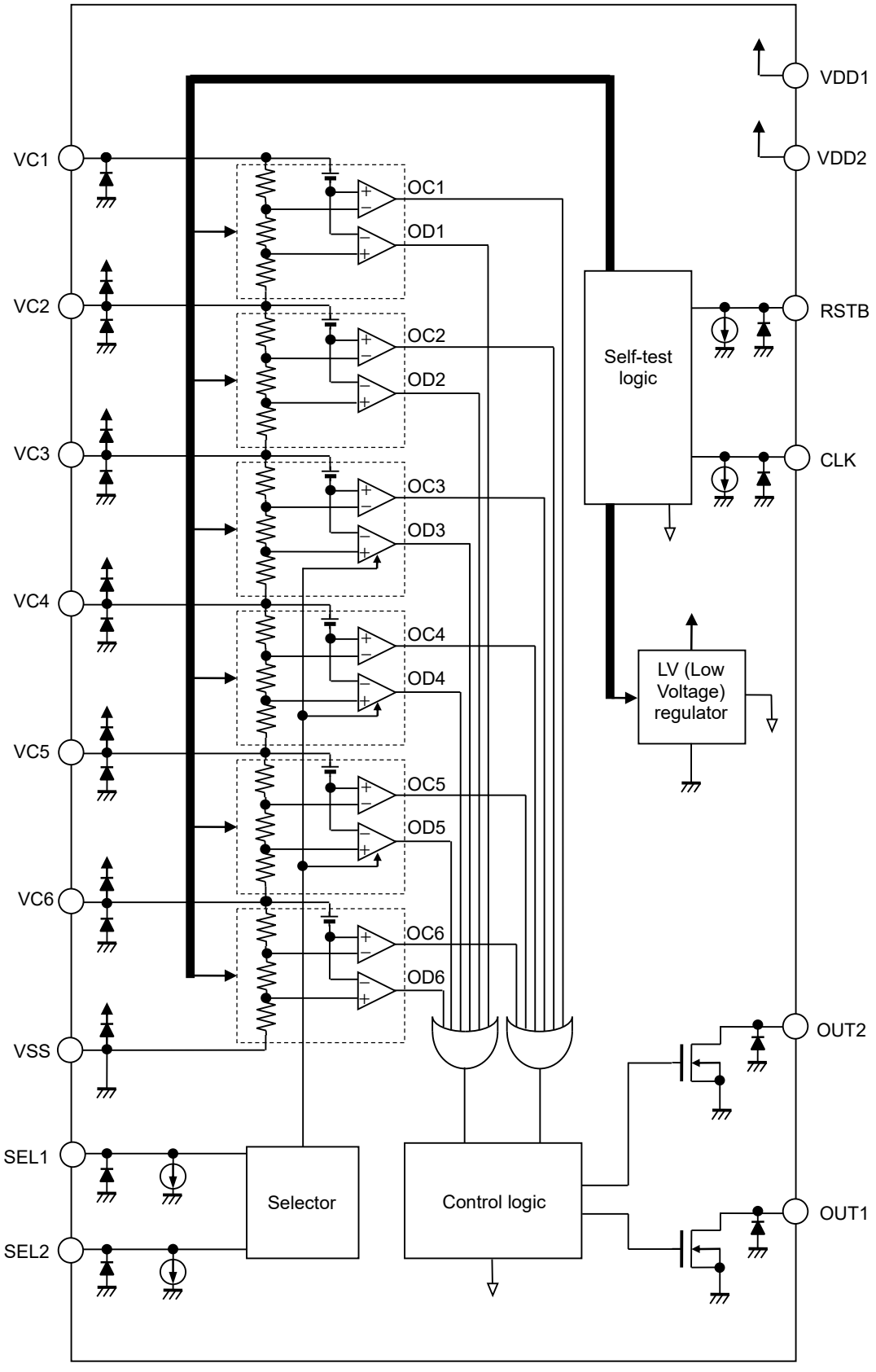


Figure 2

Remark The diodes in the figure are parasitic diodes.

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■ AEC-Q100 Qualified

This IC supports AEC-Q100 for the operation temperature grade 2.
Contact our sales representatives for details of AEC-Q100 reliability specification.

■ Product Name Structure

1. Product name

S-19192 xxx H - BCT1 U

- Environmental code
  - U: Lead-free (Sn 100%), halogen-free
- Package abbreviation and IC packing specifications*1
  - BCT1: HTSSOP-16, Tape
- Operation temperature
  - H: Ta = −40°C to +105°C
- Serial code*2
  - Sequentially set from AAA to ZZZ

*1. Refer to the tape drawing.
*2. Refer to "**3. Product name list**".

2. Package

Table 1 Package Drawing Codes

Package Name	Dimension	Tape	Reel	Land
HTSSOP-16	FR016-A-P-SD	FR016-A-C-SD	FR016-A-R-SD	FR016-A-L-SD

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3. Product name list

Table 2 (1 / 2)

Product Name	Overcharge Detection Voltage [V_{CU}]	Overcharge Release Voltage [V_{CL}]	Overdischarge Detection Voltage [V_{DL}]	Overdischarge Release Voltage [V_{DU}]	Detection Delay Time*1 [t_{DET}]	Release Delay Time*2 [t_{REL}]	Delay time shortening during self-test*3
S-19192AAAH-BCT1U	4.350 V	4.100 V	2.000 V	2.400 V	128 ms	2.0 ms	Unavailable
S-19192AABH-BCT1U	4.350 V	4.100 V	2.000 V	2.400 V	128 ms	2.0 ms	Unavailable
S-19192AACH-BCT1U	4.250 V	4.000 V	2.700 V	3.000 V	256 ms	2.0 ms	Unavailable
S-19192AADH-BCT1U	3.650 V	3.400 V	2.500 V	2.900 V	256 ms	2.0 ms	Unavailable
S-19192AAEH-BCT1U	4.250 V	4.000 V	2.700 V	3.000 V	256 ms	2.0 ms	Available
S-19192AAFH-BCT1U	3.650 V	3.400 V	2.500 V	2.900 V	256 ms	2.0 ms	Available
S-19192AAGH-BCT1U	3.100 V	2.800 V	1.500 V	2.200 V	256 ms	16 ms	Available

Table 2 (2 / 2)

Product Name	OUT1 Pin		OUT2 Pin			Detection Signal Type*5
	Output Form	Output Logic	Output Form	Output Logic	Output Latch*4	
S-19192AAAH-BCT1U	CMOS	Active "H"	CMOS	Active "H"	Available	Common
S-19192AABH-BCT1U	CMOS	Active "H"	CMOS	Active "H"	Available	Separate
S-19192AACH-BCT1U	CMOS	Active "H"	CMOS	Active "H"	Available	Separate
S-19192AADH-BCT1U	CMOS	Active "H"	CMOS	Active "H"	Available	Separate
S-19192AAEH-BCT1U	CMOS	Active "H"	CMOS	Active "H"	Unavailable	Separate
S-19192AAFH-BCT1U	CMOS	Active "H"	CMOS	Active "H"	Unavailable	Separate
S-19192AAGH-BCT1U	Nch open-drain	Active "H"	Nch open-drain	Active "H"	Unavailable	Separate

***1.** Detection delay time: 32 ms, 64 ms, 128 ms, 256 ms
***2.** Release delay time: 2.0 ms, 4.0 ms, 8.0 ms, 16.0 ms
***3.** Refer to "**4. Delay time shortening during self-test**" in "**■ Self-test Function**" for details.
***4.** Refer to "**5. Self-test function operation examples**" in "**■ Self-test Function**" for details.
***5.** Refer to **Table 3** for details on detection signal type.

Remark Please contact our sales representatives for products other than the above.

Table 3

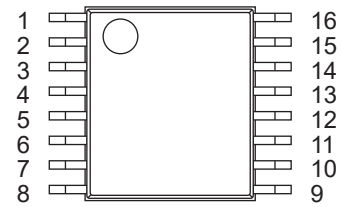
Detection Signal Type	Overcharge Detection Signal	Overdischarge Detection Signal	Self-test Result Signal
Common	OUT1 pin	OUT1 pin	OUT2 pin
Separate	OUT1 pin	OUT2 pin	OUT2 pin

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■ Pin Configuration

1. HTSSOP-16

Top view



Bottom view

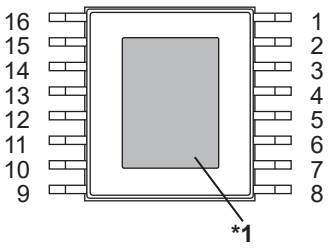


Figure 3

Table 4

Pin No.	Symbol	Description
1	VDD1*2	Input pin for positive power supply, connection pin for positive voltage of battery 1
2	VC1	Connection pin for positive voltage of battery 1
3	VC2	Connection pin for negative voltage of battery 1, connection pin for positive voltage of battery 2
4	VC3	Connection pin for negative voltage of battery 2, connection pin for positive voltage of battery 3
5	VC4	Connection pin for negative voltage of battery 3, connection pin for positive voltage of battery 4
6	VC5	Connection pin for negative voltage of battery 4, connection pin for positive voltage of battery 5
7	VC6	Connection pin for negative voltage of battery 5, connection pin for positive voltage of battery 6
8	VSS	Input pin for negative power supply, connection pin for negative voltage of battery 6
9	NC*3	No connection
10	OUT2	Output pin 2 (Refer to "■ **Operation**" and "■ **Self-test Function**")
11	OUT1	Output pin 1 (Refer to "■ **Operation**" and "■ **Self-test Function**")
12	SEL2	Switching pins for number of serial cells [SEL1, SEL2] = ["L", "L"] : 6-serial cell [SEL1, SEL2] = ["L", "H"] : 5-serial cell [SEL1, SEL2] = ["H", "L"] : 4-serial cell [SEL1, SEL2] = ["H", "H"] : 3-serial cell
13	SEL1	
14	CLK	Input pin for clock signal
15	RSTB	Input pin for reset signal
16	VDD2*2	Input pin for positive power supply, connection pin for positive voltage of battery 1

***1.** Connect the heat sink of backside at shadowed area to the board, and set electric potential open.
However, do not use it as the function of electrode.
***2.** Be sure to connect both the VDD1 pin and the VDD2 pin to the positive power supply.
***3.** The NC pin is electrically open.
The NC pin can be connected to the VDD pin or the VSS pin.

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■ Absolute Maximum Ratings

Table 5

(Ta = +25°C unless otherwise specified)

Item		Symbol	Applied Pin	Absolute Maximum Rating	Unit
Input voltage between VDD pin and VSS pin		V_{DS}	VDD1, VDD2	V_{SS} – 0.3 to V_{SS} + 28.0	V
Input pin voltage		V_{IN}	VC1, VC2, VC3, VC4, VC5, VC6, SEL1, SEL2, RSTB, CLK	V_{SS} – 0.3 to V_{DD} + 0.3 ≤ V_{SS} + 28.0	V
Output pin voltage	CMOS output	V_{OUT}	OUT1, OUT2	V_{SS} – 0.3 to V_{DD} + 0.3 ≤ V_{SS} + 28.0	V
	Nch open-drain output			V_{SS} – 0.3 to V_{SS} + 28.0	V
Operation ambient temperature		T_{opr}	–	–40 to +105	°C
Storage temperature		T_{stg}	–	–40 to +125	°C

Caution The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.

■ Thermal Resistance Value

Table 6

Item	Symbol	Condition		Min.	Typ.	Max.	Unit
Junction-to-ambient thermal resistance*1	θ_{JA}	HTSSOP-16	Board A	–	91	–	°C/W
			Board B	–	65	–	°C/W
			Board C	–	34	–	°C/W
			Board D	–	32	–	°C/W
			Board E	–	26	–	°C/W

***1.** Test environment: compliance with JEDEC STANDARD JESD51-2A

Remark Refer to "■ **Power Dissipation**" and "**Test Board**" for details.

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■ Electrical Characteristics

Table 7 (1 / 2)

(V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V, Ta = +25°C unless otherwise specified)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Detection Voltage						
Overcharge detection voltage n (n = 1 to 6)	V_{CUn}	–	V_{CUn} – 0.020	V_{CUn}	V_{CUn} + 0.020	V
		Ta = –5°C to +55°C*1	V_{CUn} – 0.030	V_{CUn}	V_{CUn} + 0.030	V
Overdischarge detection voltage n (n = 1 to 6)	V_{DLn}	–	V_{DLn} – 0.080	V_{DLn}	V_{DLn} + 0.080	V
Release Voltage		–				
Overcharge release voltage n (n = 1 to 6)	V_{CLn}	–	V_{CLn} – 0.050	V_{CLn}	V_{CLn} + 0.050	V
Overdischarge release voltage n (n = 1 to 6)	V_{DUn}	–	V_{DUn} – 0.100	V_{DUn}	V_{DUn} + 0.100	V
Input Voltage						
Operation voltage between VDD pin and VSS pin	V_{DSOP}	–	6.0	–	28.0	V
SEL1 pin voltage "H"	V_{SEL1H}	–	V_{DS} – 0.5	–	–	V
SEL1 pin voltage "L"	V_{SEL1L}	–	–	–	0.5	V
SEL2 pin voltage "H"	V_{SEL2H}	–	V_{DS} – 0.5	–	–	V
SEL2 pin voltage "L"	V_{SEL2L}	–	–	–	0.5	V
RSTB pin voltage "H"	V_{RSTBH}	–	1.6	–	–	V
RSTB pin voltage "L"	V_{RSTBL}	–	–	–	0.5	V
CLK pin voltage "H"	V_{CLKH}	–	1.6	–	–	V
CLK pin voltage "L"	V_{CLKL}	–	–	–	0.5	V

***1.** Since products are not screened at high and low temperature, the specification for this temperature range is guaranteed by design, not tested in production.

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Table 7 (2 / 2)

($V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1$ V, Ta = +25°C unless otherwise specified)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Input Current						
Current consumption during operation	I_{OPE}	–	–	10	18	µA
Current consumption during overcharge	I_{OPEC}	V1 = V2 = V3 = V4 = V5 = V6 = V_{CU} + 0.1 V	–	–	18	µA
Current consumption during overdischarge	I_{OPED}	V1 = V2 = V3 = V4 = V5 = V6 = V_{DL} – 0.1 V	–	–	18	µA
VC1 pin current	I_{VC1}	–	–	1.5	2.0	µA
VC2 pin current	I_{VC2}	–	–0.1	0.0	0.1	µA
VC3 pin current	I_{VC3}	–	–0.1	0.0	0.1	µA
VC4 pin current	I_{VC4}	–	–0.1	0.0	0.1	µA
VC5 pin current	I_{VC5}	–	–0.1	0.0	0.1	µA
VC6 pin current	I_{VC6}	–	–0.1	0.0	0.1	µA
SEL1 pin sink current	I_{SEL1H}	$V_{SEL1} = V_{DS}$	–	1.0	4.0	µA
SEL1 pin leakage current	I_{SEL1L}	V_{SEL1} = 0 V	–0.1	–	0.1	µA
SEL2 pin sink current	I_{SEL2H}	$V_{SEL2} = V_{DS}$	–	1.0	4.0	µA
SEL2 pin leakage current	I_{SEL2L}	V_{SEL2} = 0 V	–0.1	–	0.1	µA
RSTB pin sink current	I_{RSTBH}	$V_{RSTB} = V_{DS}$	–	1.0	4.0	µA
RSTB pin leakage current	I_{RSTBL}	V_{RSTB} = 0 V	–0.1	–	0.1	µA
CLK pin sink current	I_{CLKH}	$V_{CLK} = V_{DS}$	–	1.0	4.0	µA
CLK pin leakage current	I_{CLKL}	V_{CLK} = 0 V	–0.1	–	0.1	µA
Output Current						
OUT1 pin, OUT2 pin output current (output form: CMOS output)						
OUT1 pin source current	I_{OUT1H}	–	–	–	–300	µA
OUT1 pin sink current	I_{OUT1L}	–	300	–	–	µA
OUT2 pin source current	I_{OUT2H}	–	–	–	–300	µA
OUT2 pin sink current	I_{OUT2L}	–	300	–	–	µA
OUT1 pin, OUT2 pin output current (output form: Nch open-drain output)						
OUT1 pin sink current	I_{OUT1L}	–	300	–	–	µA
OUT1 pin leakage current	I_{OUT1HL}	–	–	–	0.1	µA
OUT2 pin sink current	I_{OUT2L}	–	300	–	–	µA
OUT2 pin leakage current	I_{OUT2HL}	–	–	–	0.1	µA
Delay Time						
Detection delay time	t_{DET}	–	$t_{DET} \times 0.8$	t_{DET}	$t_{DET} \times 1.2$	ms
Release delay time	t_{REL}	–	$t_{REL} \times 0.8$	t_{REL}	$t_{REL} \times 1.2$	ms
Delay Time during Self-test						
Overcharge detection delay time	t_{DETDC}	–	$t_{DET} \times 0.7$	t_{DET}	$t_{DET} \times 1.3$	ms
Overdischarge detection delay time	t_{DETDD}	–	$t_{DET} \times 0.7$	t_{DET}	$t_{DET} \times 1.3$	ms
Overcharge release delay time	t_{RELDC}	–	$t_{REL} \times 0.7$	t_{REL}	$t_{REL} \times 1.3$	ms
Overdischarge release delay time	t_{RELDD}	–	$t_{REL} \times 0.7$	t_{REL}	$t_{REL} \times 1.3$	ms

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■ Test Circuit

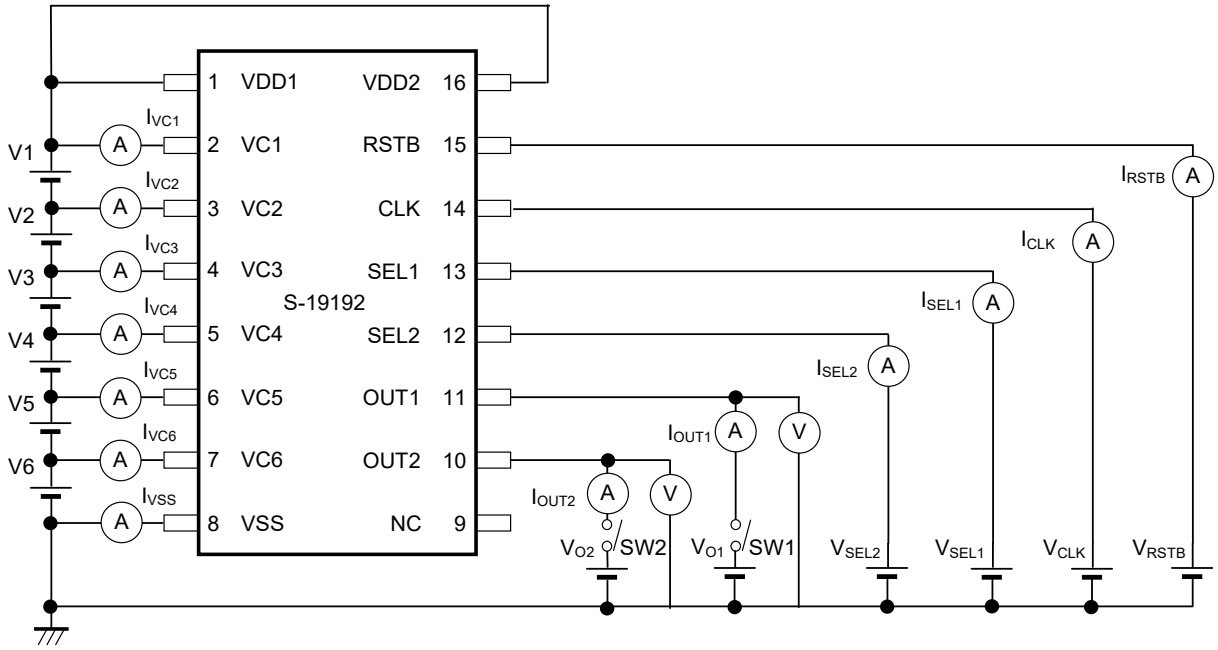


Figure 4

Remark Set SW1 and SW2 to OFF unless otherwise specified.

1. Overcharge detection voltage n (V_{CUn}), overcharge release voltage n (V_{CLn})

After setting V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V and V_{RSTB} = V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, the voltage V1 is gradually increased. When the OUT1 pin output switches to the detection status, the voltage V1 is defined as V_{CU1}. The voltage V1 is then gradually decreased. When the OUT1 pin output switches to the release status, the voltage V1 is defined as V_{CL1}. Similarly, V_{CUn} and V_{CLn} can be defined by changing Vn (n = 2 to 6).

2. Overdischarge detection voltage n (V_{DLn}), overdischarge release voltage n (V_{DUn})

After setting V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V and V_{RSTB} = V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, the voltage V1 is gradually decreased. When the OUT1 pin output or OUT2 pin output*1 switches to the detection status, the voltage V1 is defined as V_{DL1}. The voltage V1 is then gradually increased. When the OUT1 pin output or OUT2 pin output*1 switches to the release status, the voltage V1 is defined as V_{DU1}. Similarly, V_{DLn} and V_{DUn} can be defined by changing Vn (n = 2 to 6).

*1. When the detection signal type is "common", it is OUT1 pin output.
When the detection signal type is "separate", it is OUT2 pin output.

3. SEL1 pin voltage "H" (V_{SEL1H}), SEL1 pin voltage "L" (V_{SEL1L}), SEL2 pin voltage "H" (V_{SEL2H}), SEL2 pin voltage "L" (V_{SEL2L})

After setting V1 = V2 = V3 = V4 = V6 = V_{DU} + 0.1 V, V_{RSTB} = V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, and V5 = V_{DL} – 0.1 V, the voltage V_{SEL1} is gradually increased. When the OUT1 pin output switches to the release status, the voltage V_{SEL1} is defined as V_{SEL1H}. The voltage V_{SEL1} is then gradually decreased. When the OUT1 pin output switches to the detection status, the voltage V_{SEL1} is defined as V_{SEL1L}. Similarly, V_{SEL2H} and V_{SEL2L} can be defined by changing V_{SEL2}.

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4. RSTB pin voltage "H" (V_{RSTBH}), RSTB pin voltage "L" (V_{RSTBL}), CLK pin voltage "H" (V_{CLKH}), CLK pin voltage "L" (V_{CLKL})

After setting V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V, V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, and V_{RSTB} = V_{DS}, the voltage V1 is increased to V_{CU} + 0.1 V. OUT1 pin output and OUT2 pin output then switch to the detection status, and after that, the voltage V_{RSTB} is gradually decreased. When the OUT2 pin output switches to the release status, the voltage V_{RSTB} is defined as V_{RSTBL}. Following the above, V_{RSTB} is gradually increased. When the OUT2 pin output switches to the detection status, the voltage V_{RSTB} is defined as V_{RSTBH}.
After setting V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V, V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, and V_{RSTB} = V_{DS}, the voltage V_{CLK} is gradually increased. When the OUT1 pin output and OUT2 pin output switch to the detection status, the voltage V_{CLK} is defined as V_{CLKH}. After that, V_{CLK} is gradually decreased. When the OUT1 pin output and OUT2 pin output switch to the release status, V_{CLK} is defined as V_{CLKL}.

5. Current consumption during operation (I_{OPE}), current consumption during overcharge (I_{OPEC}), current consumption during overdischarge (I_{OPED})

When V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V and V_{RSTB} = V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, the VSS pin current is defined as I_{OPE}.
When V1 = V2 = V3 = V4 = V5 = V6 = V_{CU} + 0.1 V and V_{RSTB} = V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, the VSS pin current is defined as I_{OPEC}.
When V1 = V2 = V3 = V4 = V5 = V6 = V_{DL} − 0.1 V and V_{RSTB} = V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, the VSS pin current is defined as I_{OPED}.

6. VCn pin current (I_{VCn}) (n = 1 to 6)

When V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V and V_{RSTB} = V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, the VCn pin current is defined as I_{VCn}.

7. SEL1 pin sink current (I_{SEL1H}), SEL1 pin leakage current (I_{SEL1L}), SEL2 pin sink current (I_{SEL2H}), SEL2 pin leakage current (I_{SEL2L})

When V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V and V_{RSTB} = V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, the SEL1 pin current and SEL2 pin current are defined as I_{SEL1L} and I_{SEL2L}, respectively.
When V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V, V_{RSTB} = V_{CLK} = V_{SEL2} = 0 V, and V_{SEL1} = V_{DS}, the SEL1 pin current is defined as I_{SEL1H}.
When V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V, V_{RSTB} = V_{CLK} = V_{SEL1} = 0 V, and V_{SEL2} = V_{DS}, the SEL2 pin current is defined as I_{SEL2H}.

8. RSTB pin sink current (I_{RSTBH}), RSTB pin leakage current (I_{RSTBL}), CLK pin sink current (I_{CLKH}), CLK pin leakage current (I_{CLKL})

When V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V and V_{RSTB} = V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, the RSTB pin current and CLK pin current are defined as I_{RSTBL} and I_{CLKL}, respectively.
When V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V, V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, and V_{RSTB} = V_{DS}, the RSTB pin current is defined as I_{RSTBH}.
When V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V, V_{RSTB} = V_{SEL1} = V_{SEL2} = 0 V, and V_{CLK} = V_{DS}, the CLK pin current is defined as I_{CLKH}.

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9. OUT1 pin source current (I_{OUT1H}), OUT1 pin sink current (I_{OUT1L}), OUT1 pin leakage current (I_{OUT1HL}), OUT2 pin source current (I_{OUT2H}), OUT2 pin sink current (I_{OUT2L}), OUT2 pin leakage current (I_{OUT2HL})

9. 1 CMOS output, active "H"

When V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V, V_{RSTB} = V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, V_{O1} = V_{O2} = 0.5 V, and SW1 = ON, the OUT1 pin current is I_{OUT1L}. Similarly, when SW2 = ON, the OUT2 pin current is I_{OUT2L}.
When V1 = V2 = V3 = V4 = V5 = V6 = V_{CU} + 0.1 V, V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, V_{RSTB} = V_{DS}, V_{O1} = V_{O2} = V_{DS} − 0.5 V, and SW1 = ON, the OUT1 pin current is I_{OUT1H}. Similarly, when SW2 = ON, the OUT2 pin current is I_{OUT2H}.

9. 2 CMOS output, active "L"

When V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V, V_{RSTB} = V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, V_{O1} = V_{O2} = V_{DS} − 0.5 V, and SW1 = ON, the OUT1 pin current is I_{OUT1H}. Similarly, when SW2 = ON, the OUT2 pin current is I_{OUT2H}.
When V1 = V2 = V3 = V4 = V5 = V6 = V_{CU} + 0.1 V, V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, V_{RSTB} = V_{DS}, V_{O1} = V_{O2} = 0.5 V, and SW1 = ON, the OUT1 pin current is I_{OUT1L}. Similarly, when SW2 = ON, the OUT2 pin current is I_{OUT2L}.

9. 3 Nch open-drain output, active "H"

When V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V, V_{RSTB} = V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, V_{O1} = V_{O2} = 0.5 V, and SW1 = ON, the OUT1 pin current is I_{OUT1L}. Similarly, when SW2 = ON, the OUT2 pin current is I_{OUT2L}.
When V1 = V2 = V3 = V4 = V5 = V6 = V_{CU} + 0.1 V, V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, V_{RSTB} = V_{DS}, V_{O1} = V_{O2} = V_{DS}, and SW1 = ON, the OUT1 pin current is I_{OUT1HL}. Similarly, when SW2 = ON, the OUT2 pin current is I_{OUT2HL}.

9. 4 Nch open-drain output, active "L"

When V1 = V2 = V3 = V4 = V5 = V6 = V_{CU} + 0.1 V, V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, V_{RSTB} = V_{DS}, V_{O1} = V_{O2} = 0.5 V, and SW1 = ON, the OUT1 pin current is I_{OUT1L}. Similarly, when SW2 = ON, the OUT2 pin current is I_{OUT2L}.
When V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V, V_{RSTB} = V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, V_{O1} = V_{O2} = V_{DS}, and SW1 = ON, the OUT1 pin current is I_{OUT1HL}. Similarly, when SW2 = ON, the OUT2 pin current is I_{OUT2HL}.

10. Detection delay time (t_{DET}), release delay time (t_{REL})

After setting V1 = V2 = V3 = V4 = V5 = V6 = V_{DU} + 0.1 V, V_{RSTB} = V_{CLK} = V_{SEL1} = V_{SEL2} = 0 V, the voltage V4 is changed from V_{DU} + 0.1 V to V_{CU} + 1.0 V. The time interval from the V4 change until OUT1 pin output switches to the detection status is t_{DET}.
The voltage V4 is then changed from V_{CU} + 1.0 V to V_{DL} + 0.1 V. The time interval from the V4 change until OUT1 pin output switches to the release status is t_{REL}.
Subsequently, the voltage V4 is changed from V_{DL} + 0.1 V to V_{DL} − 1.0 V. The time interval from the V4 change until OUT1 pin output or OUT2 pin output*1 switches to the detection status is t_{DET}.
The voltage V4 is then changed from V_{DL} − 1.0 V to V_{CU} − 0.1 V. The time interval from the V4 change until OUT1 pin output or OUT2 pin output*1 switches to the release status is t_{REL}.

***1.** When the detection signal type is "common", it is OUT1 pin output.
When the detection signal type is "separate", it is OUT2 pin output.

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■ Standard Circuits

Connect the S-19192 Series according to the number of serial cells as shown below.

1. 6-serial cell (SEL1 = "L", SEL2 = "L")

1. 1 CMOS output

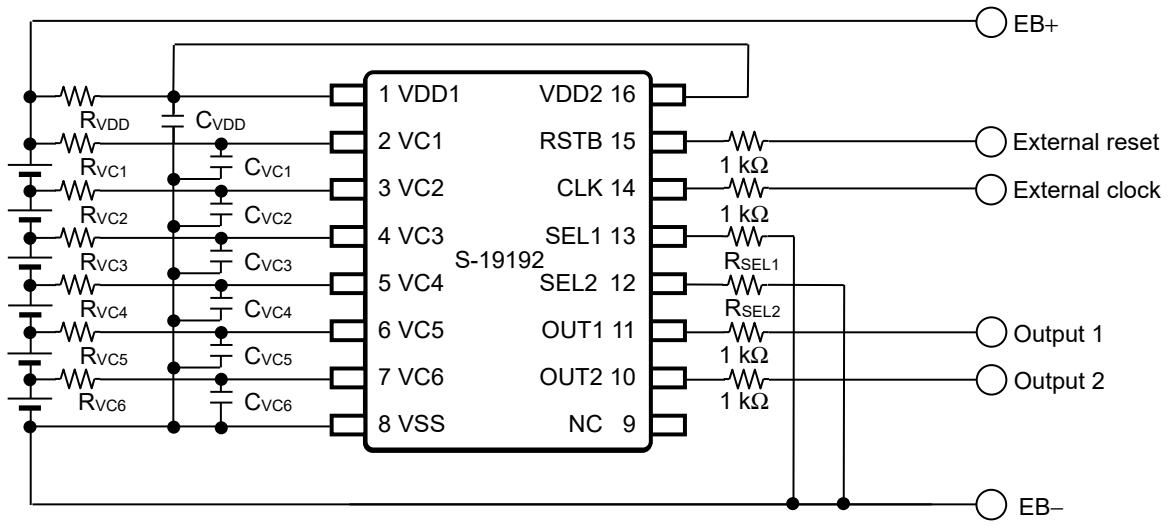


Figure 5

1. 2 Nch open-drain output

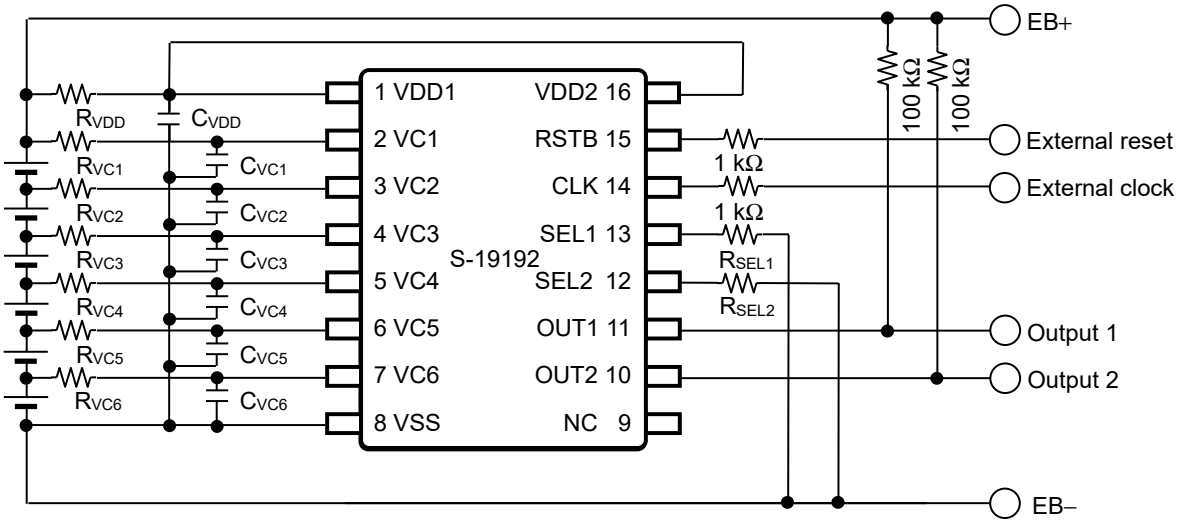


Figure 6

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2. 5-serial cell (SEL1 = "L", SEL2 = "H")

2. 1 CMOS output

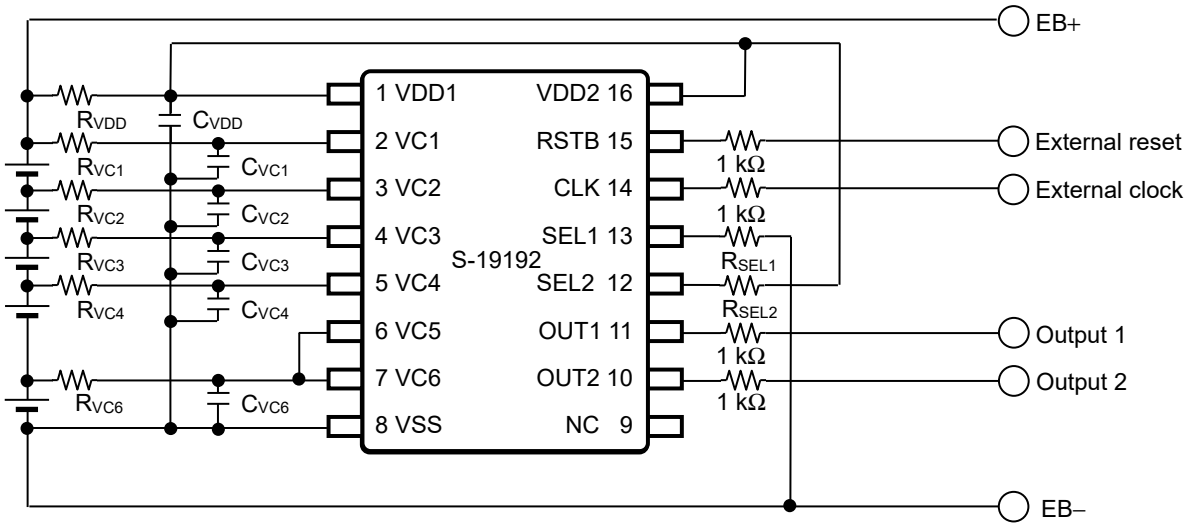


Figure 7

2. 2 Nch open-drain output

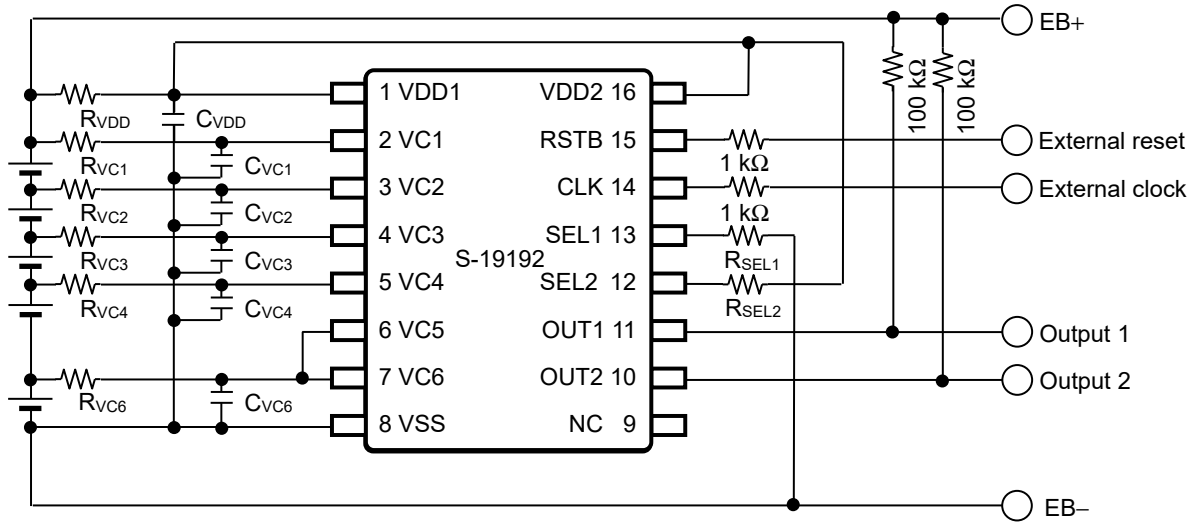


Figure 8

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3. 4-serial cell (SEL1 = "H", SEL2 = "L")

3. 1 CMOS output

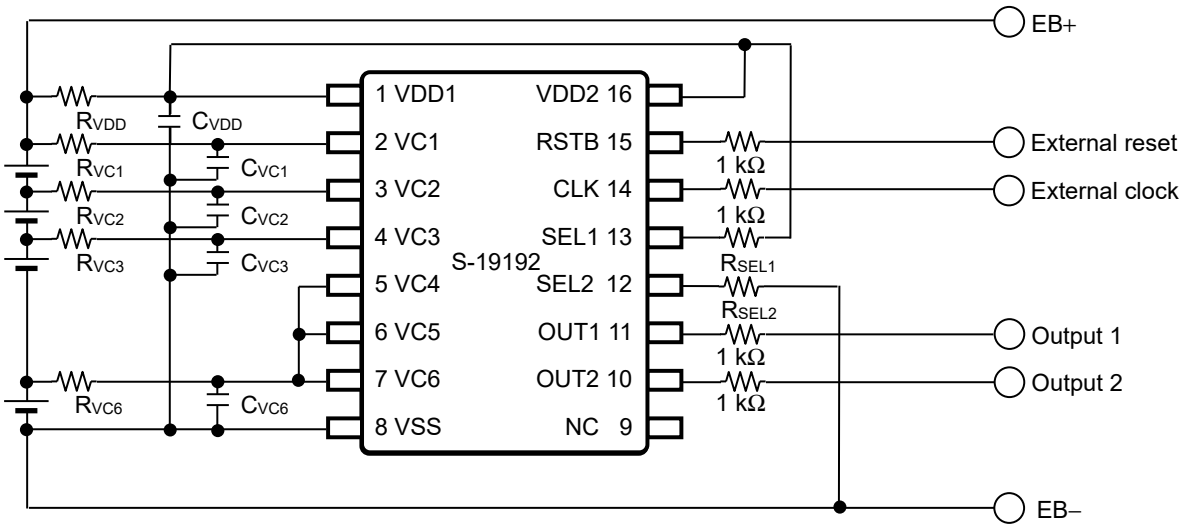


Figure 9

3. 2 Nch open-drain output

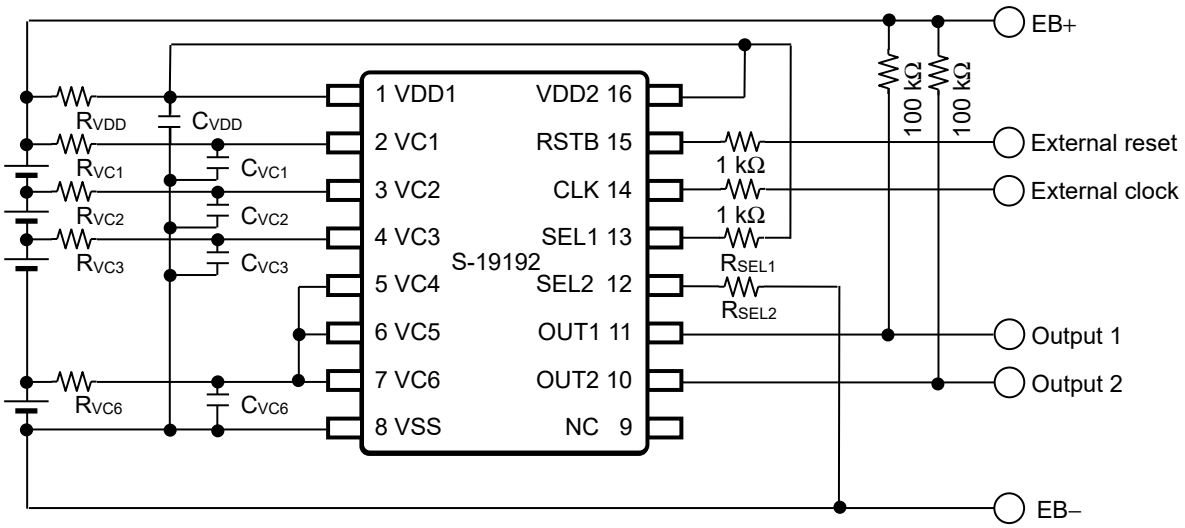


Figure 10

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4. 3-serial cell (SEL1 = "H", SEL2 = "H")

4. 1 CMOS output

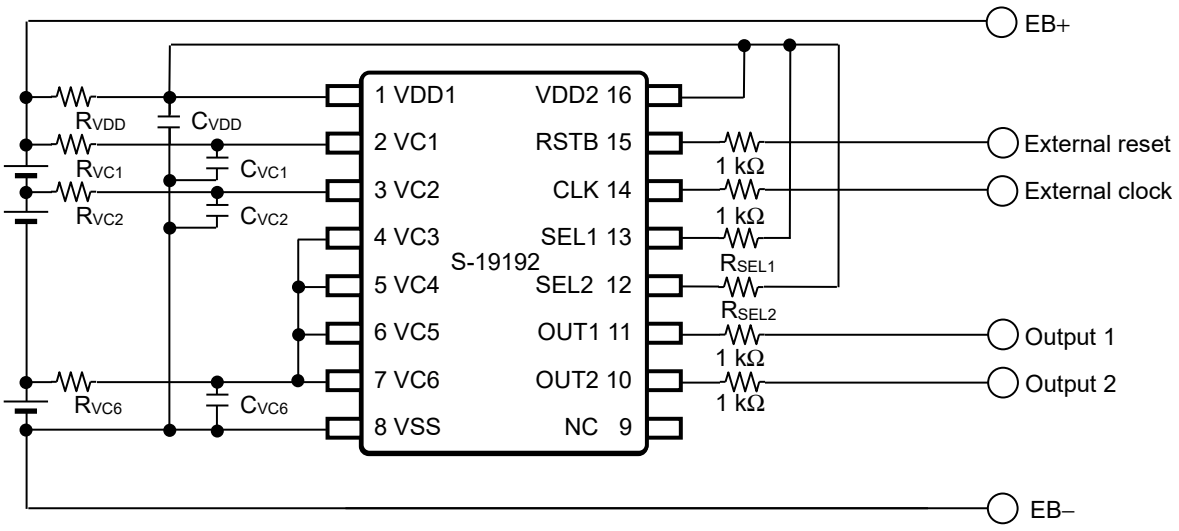


Figure 11

4. 2 Nch open-drain output

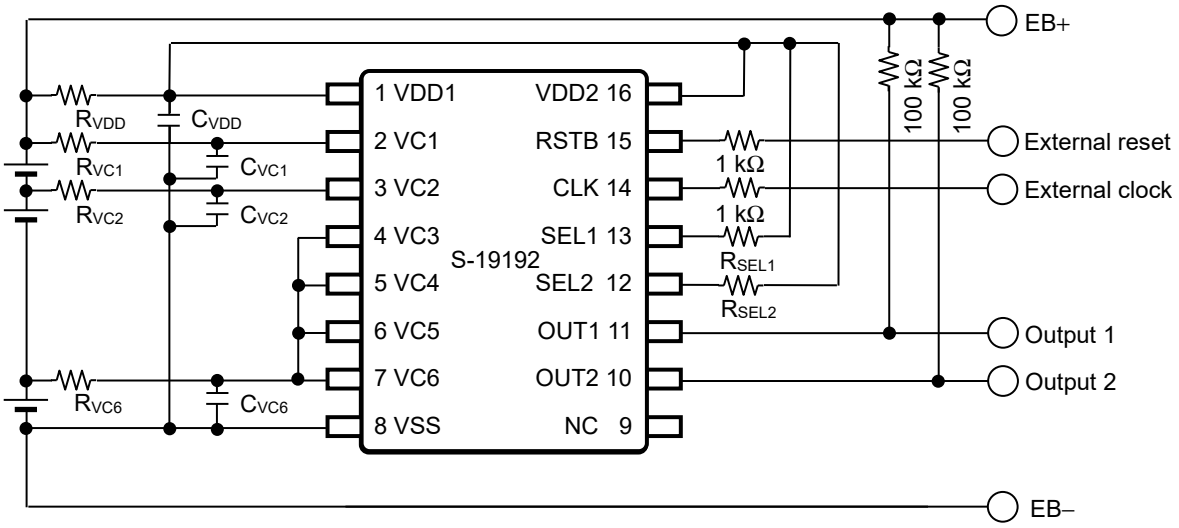


Figure 12

Table 8 Constants for External Components

Symbol	Min.	Typ.	Max.	Unit
R_{VDD}	0.5	1.0	1.0	kΩ
R_{VCn}	0.5	1.2	1.2	kΩ
R_{SEL1}, R_{SEL2}	0.5	1.0	–	kΩ
C_{VDD}	0.075	0.100	1.000	µF
C_{VCn}	0.075	0.100	1.000	µF

Caution 1. The constants may be changed without notice.
2. It has not been confirmed whether the operation is normal or not in circuits other than the connection examples. In addition, the connection examples and the constants do not guarantee proper operation. Perform thorough evaluation using the actual application to set the constants.

Remark n = 1 to 6

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■ Operation

1. Normal status

When the voltage of each of the batteries is in the range from the overcharge detection voltage n (V_{CUn}) to the overdischarge detection voltage n (V_{DLn}), and additionally, the RSTB pin input voltage (V_{RSTB}) and the CLK pin input voltage (V_{CLK}) are lower than the RSTB pin voltage "L" (V_{RSTBL}) and the CLK pin voltage "L" (V_{CLKL}), respectively, the OUT1 pin and OUT2 pin output the release signal. This is the normal status.

Remark When the OUT2 pin output is in the detection status following the initial connection with batteries, input "H" to the RSTB pin and return the input voltage to "L". S-19192 Series then returns to the normal status.

2. Overcharge status

When the voltage of any of the batteries exceeds V_{CUn} and the status continues for the detection delay time (t_{DET}) or longer, the OUT1 pin output inverts and switches to the detection status (Refer to **Figure 14**). This is the overcharge status.
When the voltage of each of the batteries falls below the overcharge release voltage n (V_{CLn}) and the status continues for the release delay time (t_{REL}) or longer, the overcharge status is released and the S-19192 Series returns to the normal status.

3. Overdischarge status

When the voltage of any of the batteries falls below V_{DLn} and the status continues for the detection delay time (t_{DET}) or longer, the OUT1 pin output or OUT2 pin output*1 inverts and switches to the detection status (Refer to **Figure 15**). This is the overdischarge status.
When the voltage of each of the batteries exceeds the overdischarge release voltage n (V_{DUn}) and the status continues for the release delay time (t_{REL}) or longer, the overdischarge status is released and the S-19192 Series returns to the normal status.

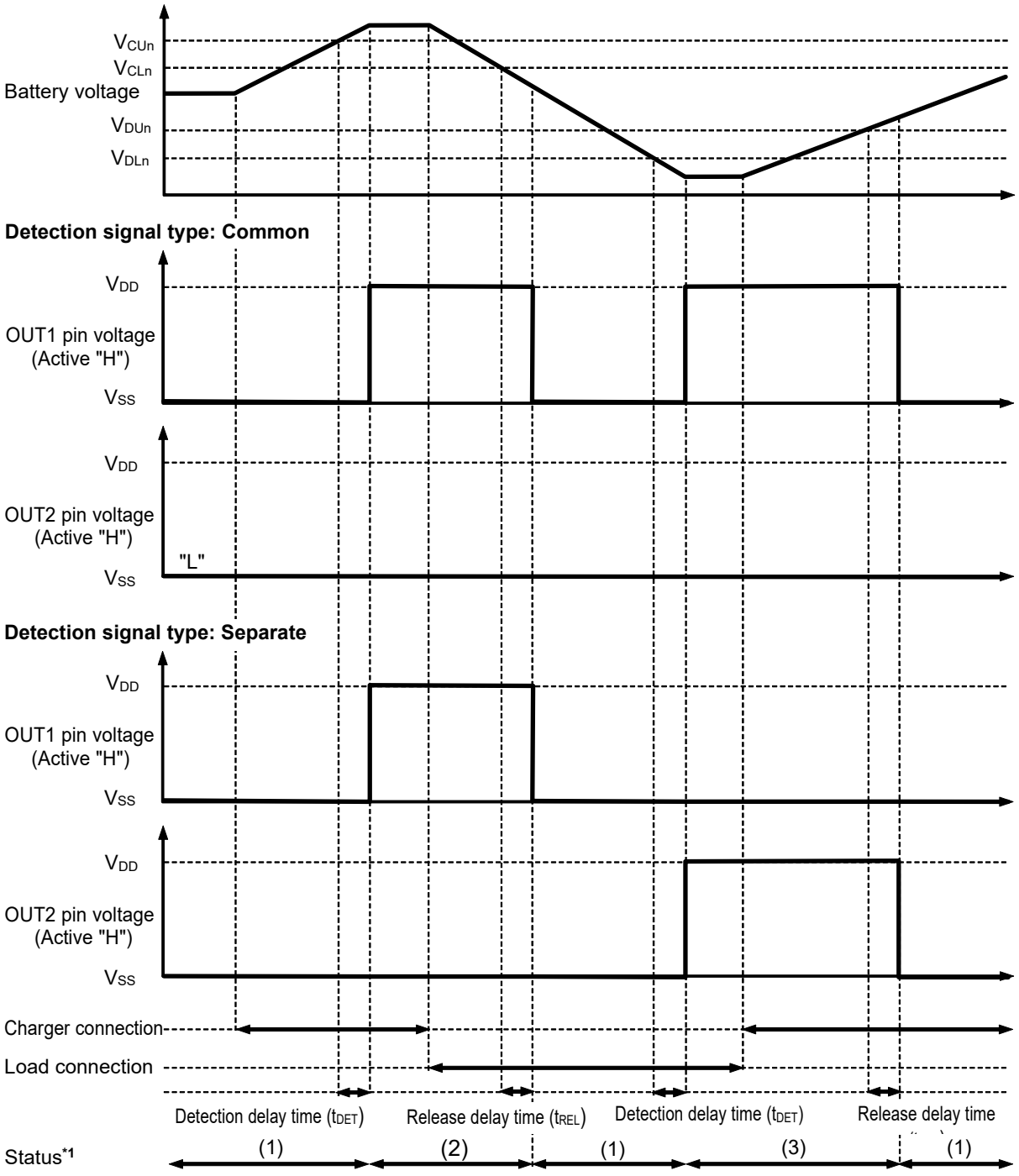
***1.** When the detection signal type is "common", it is OUT1 pin output.
When the detection signal type is "separate", it is OUT2 pin output.

Remark 1. Use the S-19192 Series within the range where the power supply voltage is 6 V or more and the voltage of each of the batteries is not lower than 1 V.
2. n = 1 to 6

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■ Timing Charts

1. Overcharge detection and overdischarge detection



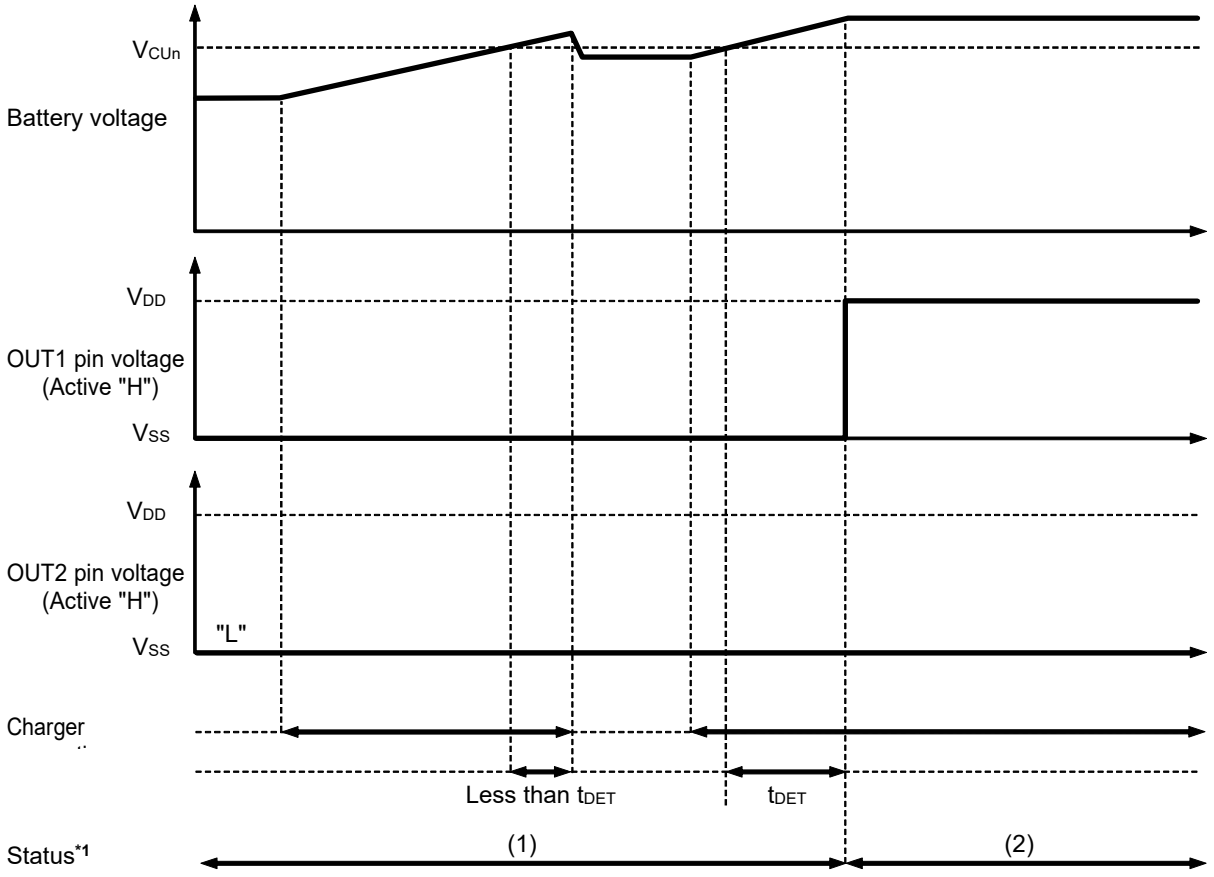
***1.** (1) : Normal status
(2) : Overcharge status
(3) : Overdischarge status

Figure 13

Remark 1. Refer to "■ **Operation**" and "■ **Self-test function**" for details of the OUT2 pin.
2. n = 1 to 6
3. V_{DD} is VDD1 pin voltage and VDD2 pin voltage.

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2. Overcharge detection delay



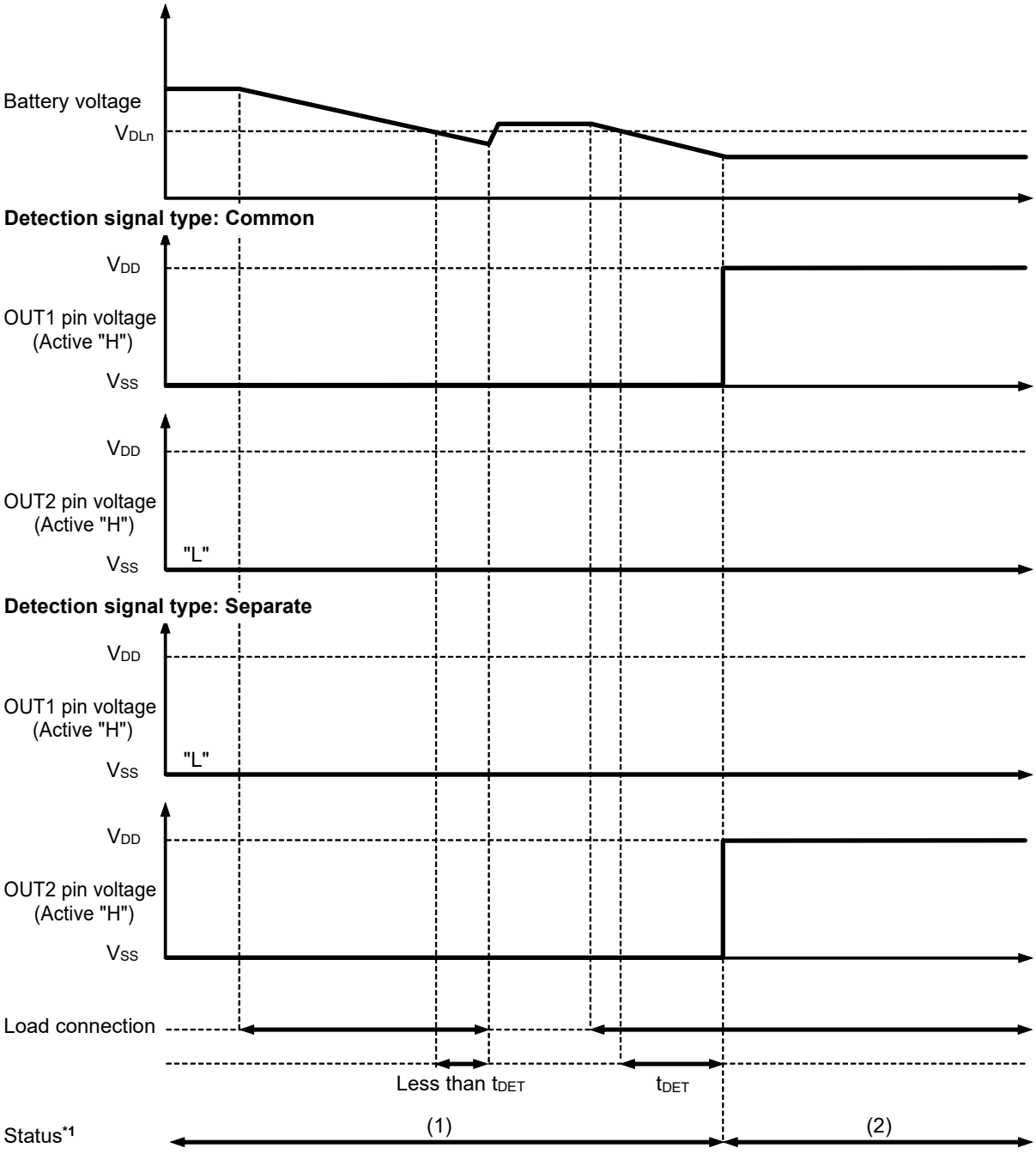
***1.** (1) : Normal status
(2) : Overcharge status

Figure 14

Remark 1. Refer to "■ **Operation**" and "■ **Self-test function**" for details of the OUT2 pin.
2. n = 1 to 6
3. V_{DD} is VDD1 pin voltage and VDD2 pin voltage.

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3. Overdischarge detection delay



***1.** (1) : Normal status
(2) : Overdischarge status

Figure 15

Remark 1. Refer to "■ **Operation**" and "■ **Self-test function**" for details of the OUT2 pin.
2. n = 1 to 6
3. V_{DD} is VDD1 pin voltage and VDD2 pin voltage.

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■ Self-test Function

The S-19192 Series has a self-test function to confirm overcharge and overdischarge detection operations. Due to the self-test function, a current flows in internal voltage-dividing resistors, comparator input voltage changes, and then the S-19192 Series spuriously switches to the overcharge or overdischarge status. It is possible to confirm whether the S-19192 Series normally detects the overcharge and overdischarge or not by monitoring the OUT1 pin and OUT2 pin output signals.

Remark **1.** When the OUT2 pin output is in the detection status following the initial connection with batteries, input "H" to the RSTB pin and return the input voltage to "L". The S-19192 Series then returns to the normal status. In order to initialize it hereafter, input voltages to the RSTB pin by the same procedure.

2. The self-test is not normally performed under the following conditions.
- When the S-19192 Series is in the overcharge or overdischarge status
- When the power supply voltage is 6 V or lower

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1. Self-test input signal

1. 1 RSTB (reset signal) input

When "H" is input to the RSTB pin, the self-test starts. When "L" is input, the S-19192 Series returns to the normal operation.

1. 2 CLK (clock signal) input

When "H" is input to the RSTB pin and clock signals are input to the CLK pin, the following diagnostics are performed.

1st clock	:	Performs overcharge comparator 1 (OC1) diagnostics
2nd clock	:	Performs overdischarge comparator 1 (OD1) diagnostics
3rd to 12th clocks	:	Performs overcharge comparator n (OCn) diagnostics at the 2n – 1th clock signal among the clock signals input to the CLK pin (Refer to **Figure 19**) Performs overdischarge comparator n (ODn) diagnostics at the 2nth clock signal among the clock signals input to the CLK pin (Refer to **Figure 21**)
13th clock	:	Does not perform any diagnostics, which makes it possible to determine at which clock diagnostics are being performed.
14th and 15th clocks	:	Performs abnormal high voltage and low voltage diagnostics for the LV regulator (Refer to **Figure 16**)

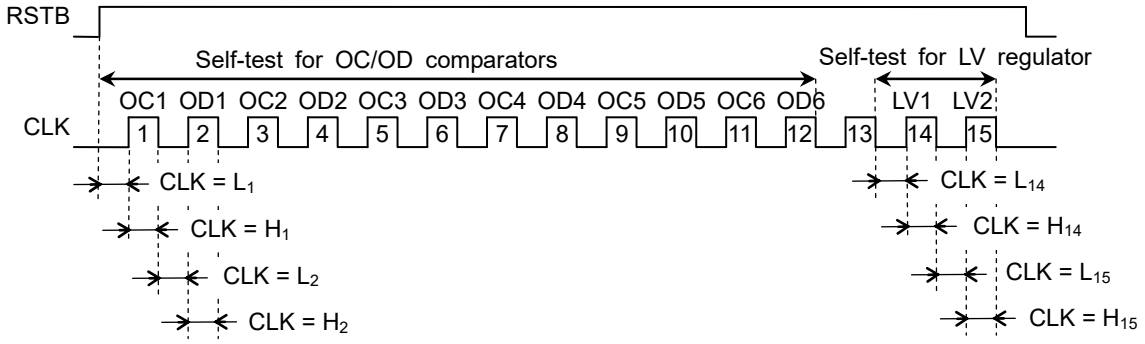


Figure 16

Remark n = 1 to 6

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1. 3 Self-test input signal timing charts

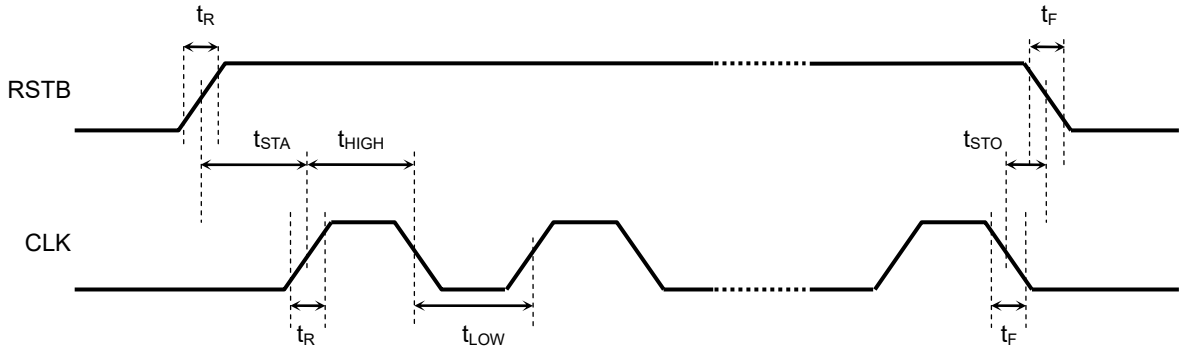


Figure 17

Remark f_{CLK} = 2.5 Hz max. (@ t_{DET} = 128 ms) ($t_{CLK} = t_{HIGH} + t_{LOW}$)
t_{LOW}, t_{HIGH}, t_{STA}, t_{STO} = $t_{DET} \times 1.5$ ms min.
t_R, t_F = 300 ns max.

f_{CLK} : CLK clock frequency
t_{CLK} : CLK clock cycle
t_{HIGH} : CLK clock high time
t_{LOW} : CLK clock low time
t_{STA} : CLK oscillation start time (Time period from a rising edge of the reset signal to self-test start)
t_{STO} : CLK oscillation stop time (Time period from self-test stop to a falling edge of the reset signal)
t_{DET} : Detection delay time
t_R : RSTB, CLK rise time
t_F : RSTB, CLK fall time

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2. Internal operation during self-test

2. 1 Self-test for overcharge detection

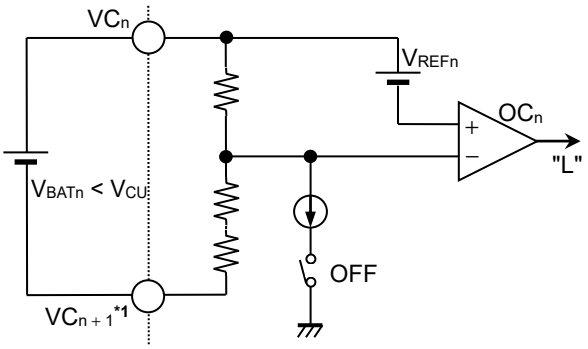


Figure 18 When Self-test Is Not Performed (RSTB = "L", CLK = "L")

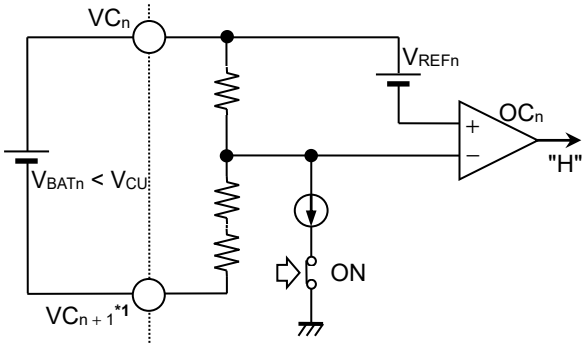


Figure 19 When Self-test Is Performed (RSTB = "H", CLK = "H_{2n-1}")

2. 2 Self-test for overdischarge detection

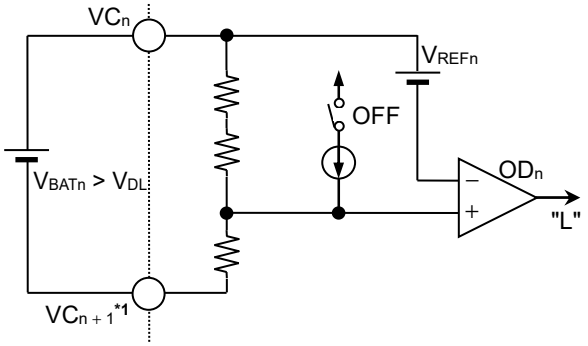


Figure 20 When Self-test Is Not Performed (RSTB = "L", CLK = "L")

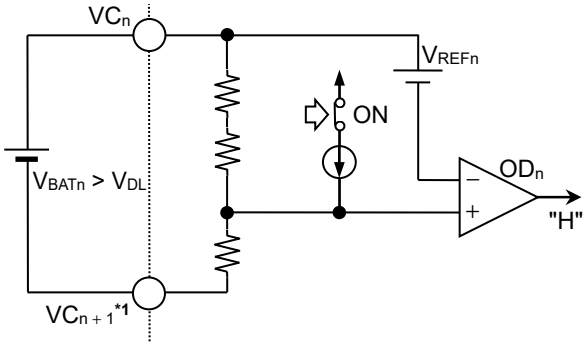


Figure 21 When Self-test Is Performed (RSTB = "H", CLK = "H_{2n}")

***1.** When n = 6, it is VSS pin.

Remark n = 1 to 6

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3. Self-test output signal

OUT1 pin and OUT2 pin outputs during self-test are shown in **Table 9**.

3. 1 No failure

3. 1. 1 Overcharge detection diagnosis

Performs overcharge detection diagnostics at the 2n − 1th clock signal among the clock signals input to the CLK pin. OUT1 pin and OUT2 pin outputs are in the overcharge detection status when the clock signal is "H" regardless of whether the detection signal type is "common" or "separate" (Refer to **Figure 19**).

3. 1. 2 Overdischarge detection diagnosis

Performs overdischarge detection diagnostics at the 2nth clock signal among the clock signals input to the CLK pin. OUT1 pin output, OUT2 pin output, or both[*1] are in the overdischarge detection status when the clock signal is "H" (Refer to **Figure 21**).

***1.** When the detection signal type is "common", it is OUT1 pin and OUT2 pin outputs during self-test.
When the detection signal type is "separate", it is OUT2 pin output only during self-test.

3. 1. 3 LV regulator diagnosis

Performs abnormal high voltage and low voltage diagnostics for the LV regulator at the 14th and 15th clock signals among the clock signals input to the CLK pin. OUT2 pin output is in the LV regulator detection status when the clock signal is "H".

3. 2 In case of failure

3. 2. 1 With self-test result output latch

OUT2 pin output retains the detection status as a self-test result after failure is detected.

3. 2. 2 Without self-test result output latch

OUT2 pin output does not retain the detection status after failure is detected (Refer to **Figure 24** and **Figure 26**).

Remark n = 1 to 6

Table 9 OUT1 Pin and OUT2 Pin Outputs during Self-test

Detection Signal Type	Failure	Output combination	
		OUT1 Pin	OUT2 Pin
Common	No failure	Overcharge detection diagnosis Overdischarge detection diagnosis	Overcharge detection diagnosis Overdischarge detection diagnosis LV regulator diagnosis
	In case of failure	Overcharge detection diagnosis Overdischarge detection diagnosis	Self-test result[*1]
Separate	No failure	Overcharge detection diagnosis	Overcharge detection diagnosis Overdischarge detection diagnosis LV regulator diagnosis
	In case of failure	Overcharge detection diagnosis	Self-test result[*1]

***1.** Refer to "**5. Operation example of self-test function** " for details.

4. Delay time shortening during self-test

Delay time during the self-test can be shortened by selecting a product for which delay time shortening during the self-test is available. In this case, each delay time is specified as follows.

- Overcharge detection delay time (t_{DETDC}): Approximately 1/64
- Overdischarge detection delay time (t_{DETDD}): Approximately 1/64
- Overcharge release delay time (t_{RELDC}): t_{REL}
- Overdischarge release delay time (t_{RELDD}): Fixed to 4 ms

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5. Operation example of self-test function

5. 1 6-serial cell, detection signal type: Common

5. 1. 1 No failure

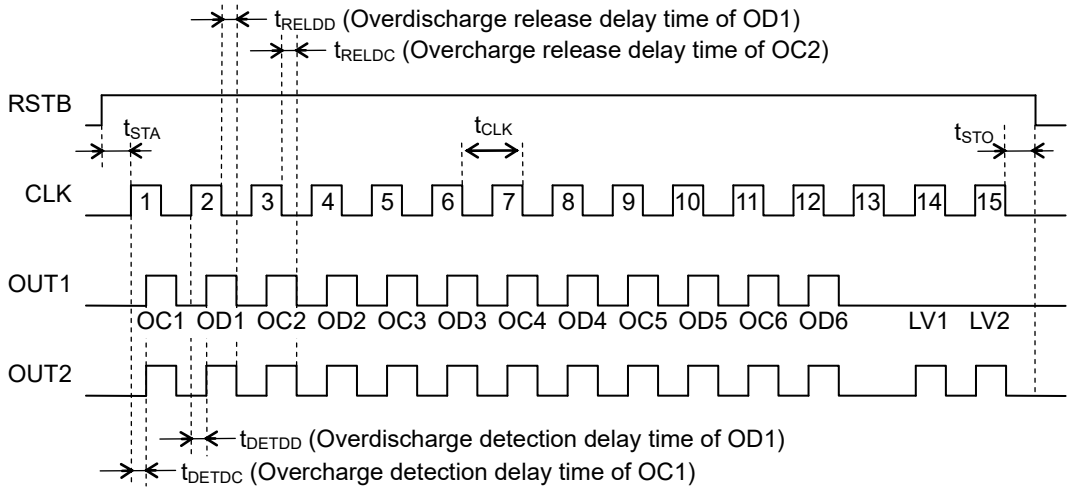


Figure 22

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5. 1. 2 When there is an overcharge detection failure (OC3)

(1) With self-test result output latch

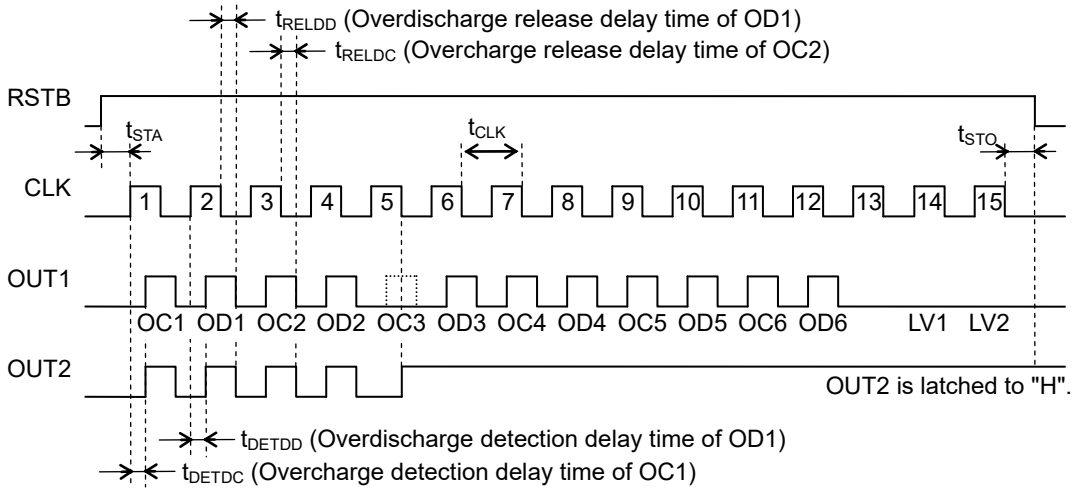


Figure 23

(2) Without self-test result output latch

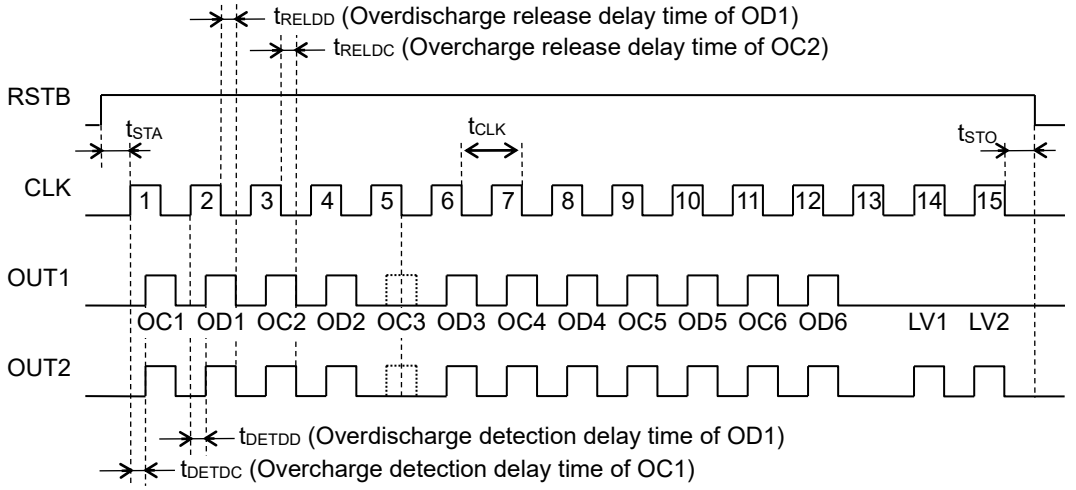


Figure 24

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5. 1. 3 When there is an LV regulator failure

(1) With self-test result output latch

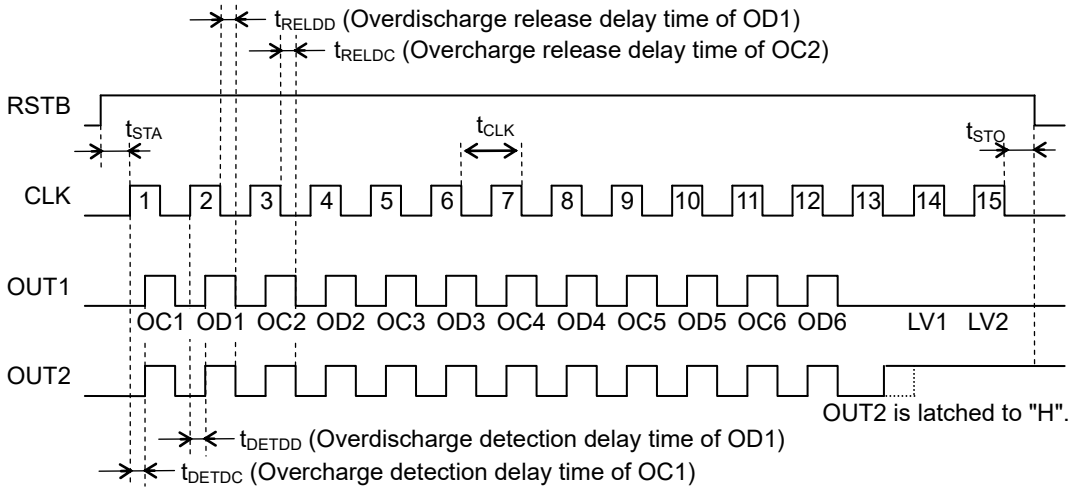


Figure 25

(2) Without self-test result output latch

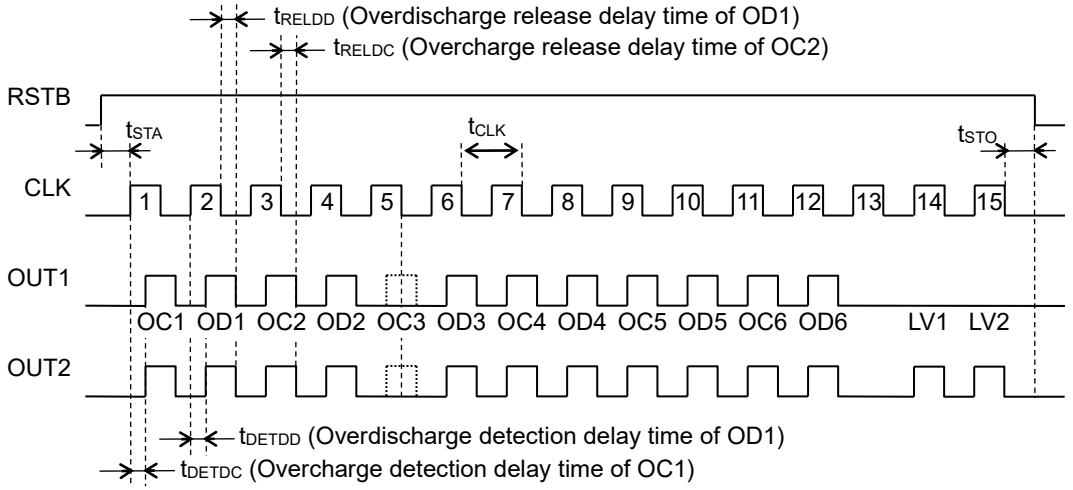


Figure 26

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5. 2 3-serial cell, detection signal type: Common

5. 2. 1 No failure

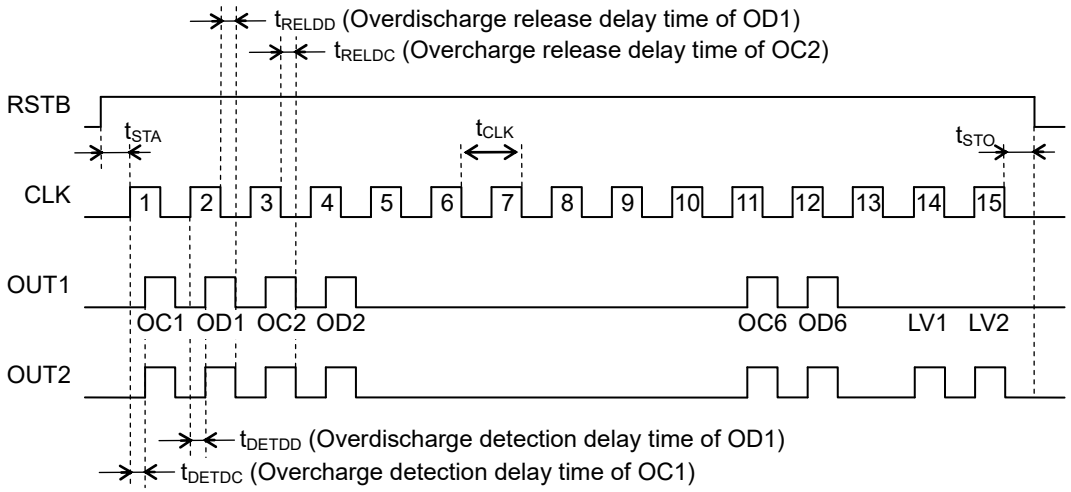


Figure 27

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5. 2. 2 When there is an overdischarge detection failure (OD2)

(1) With self-test result output latch

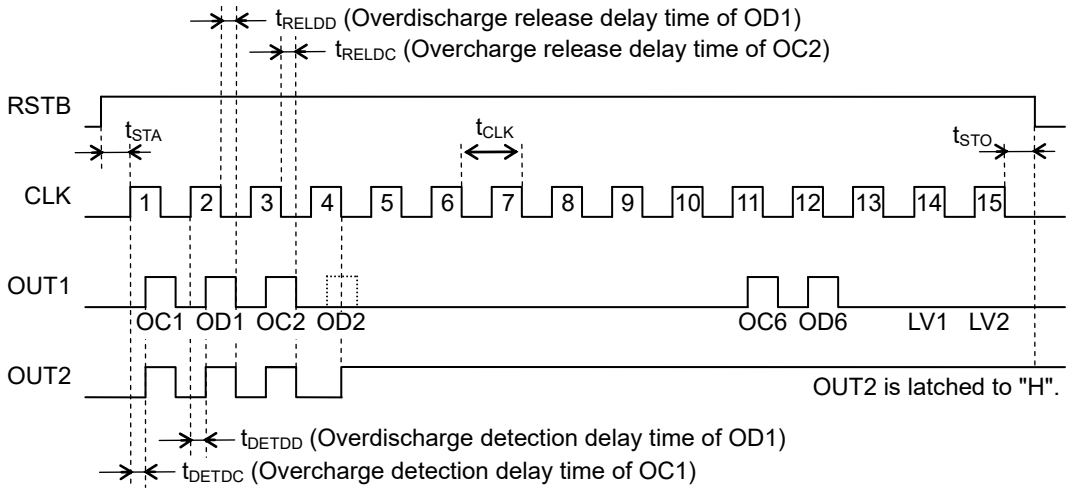


Figure 28

(2) Without self-test result output latch

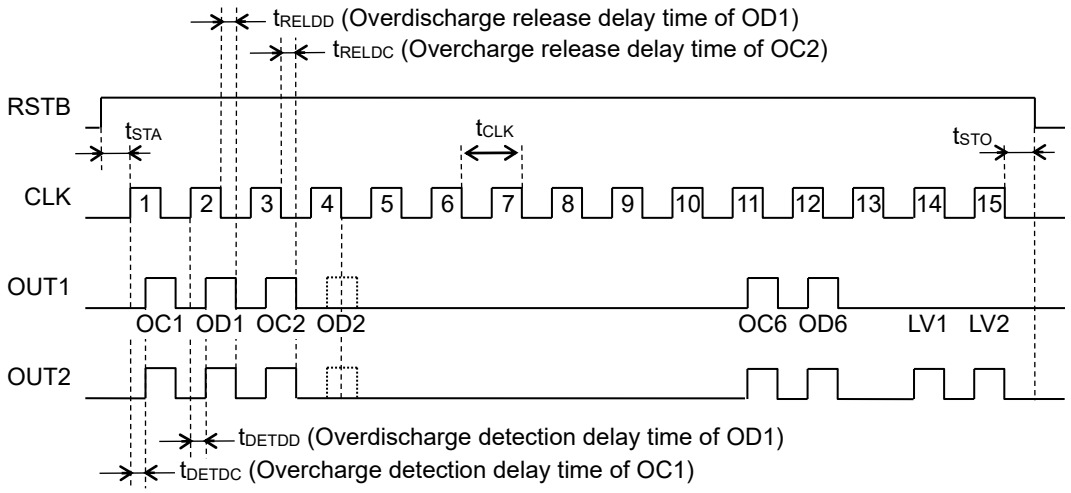


Figure 29

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5. 3 6-serial cell, detection signal type: Common (Self-test interruption)

5. 3. 1 No failure

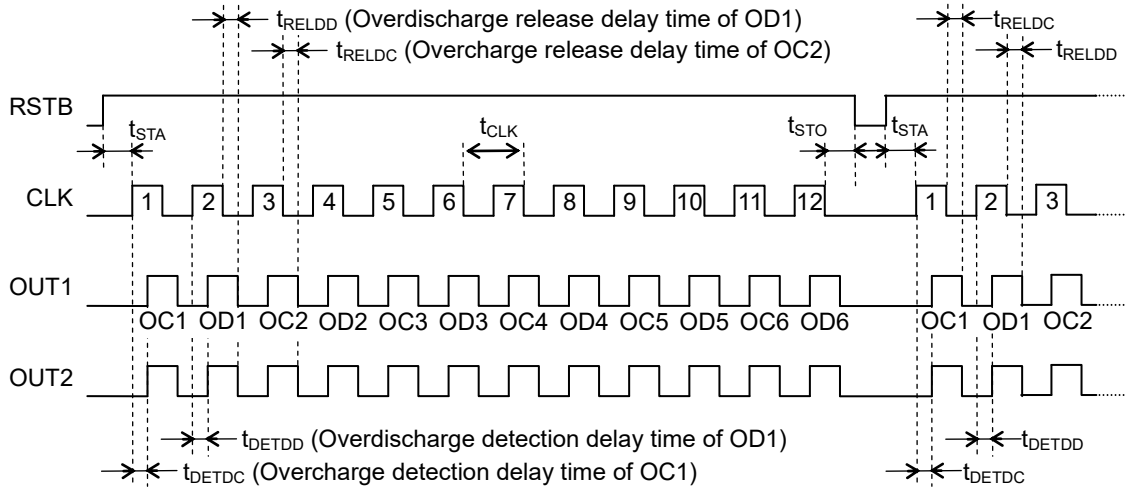


Figure 30

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5. 3. 2 When there is an overcharge detection failure (OC3)

(1) With self-test result output latch

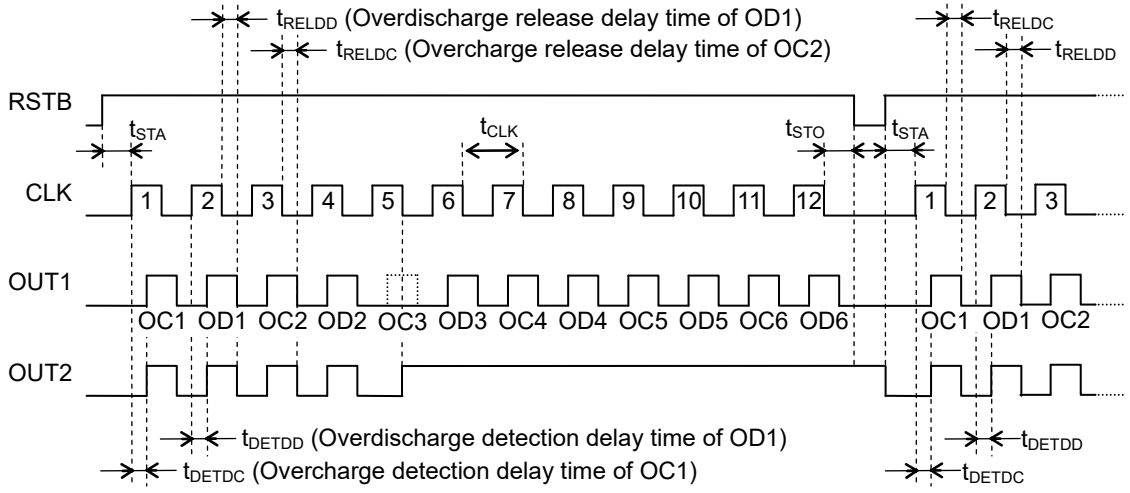


Figure 31

(2) Without self-test result output latch

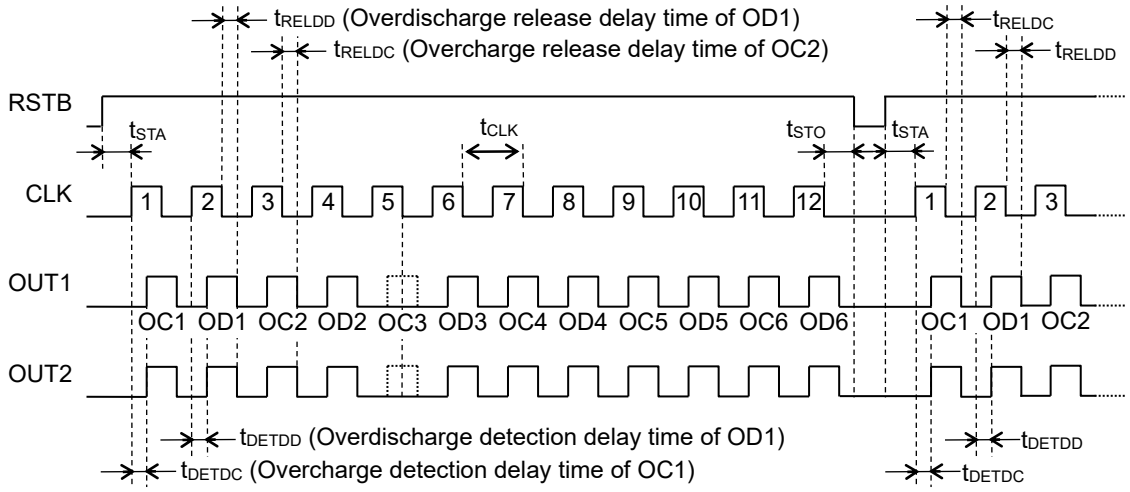


Figure 32

Downloaded from Arrow.com.

5. 4 6-serial cell, detection signal type: Separate

5. 4. 1 No failure

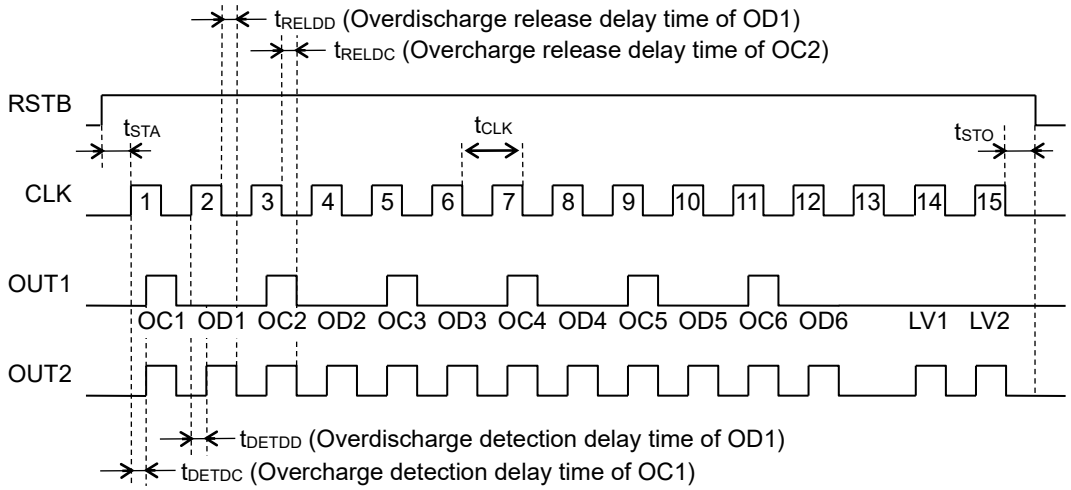


Figure 33

Downloaded from Arrow.com.

5. 4. 2 When there is an overdischarge detection failure (OD3)

(1) With self-test result output latch

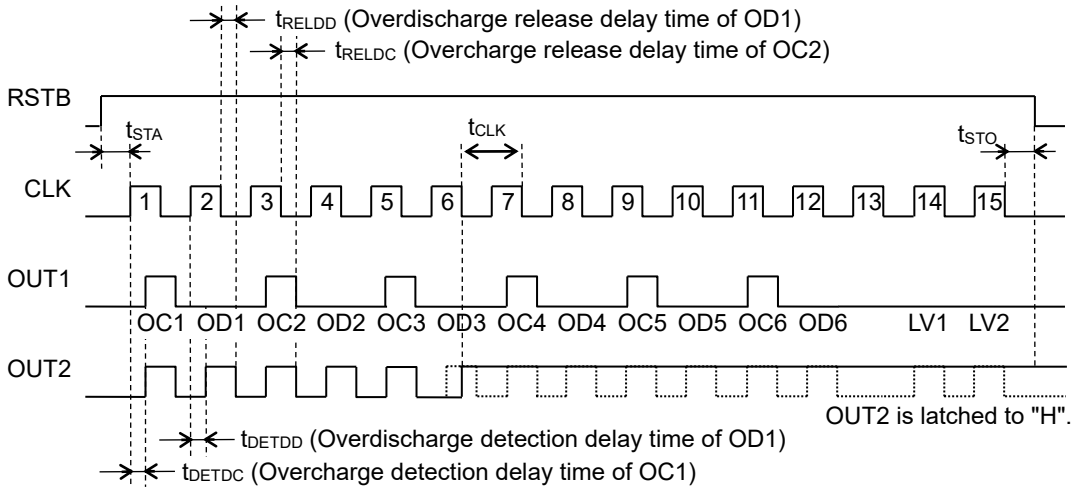


Figure 34

(2) Without self-test result output latch

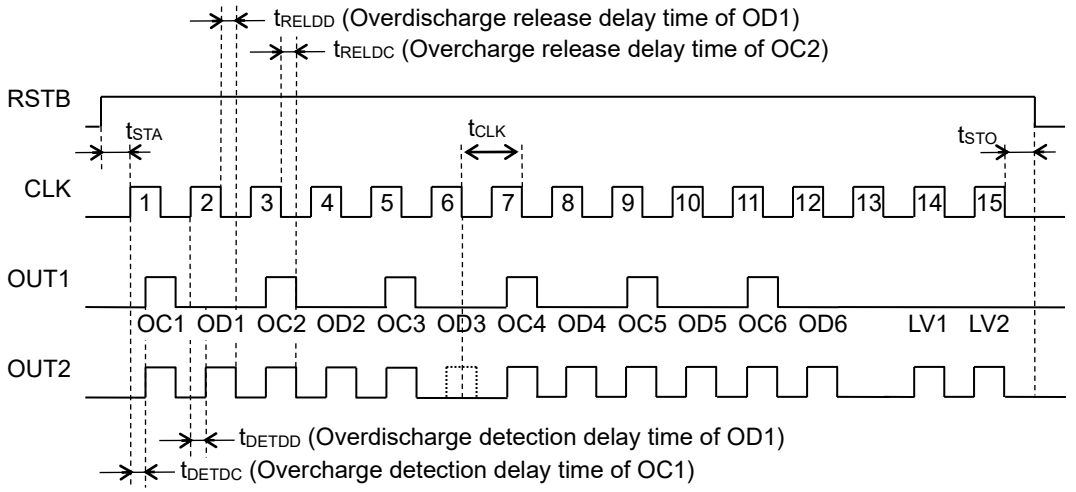


Figure 35

Downloaded from Arrow.com.

5. 4. 3 When there is an LV regulator failure

(1) With self-test result output latch

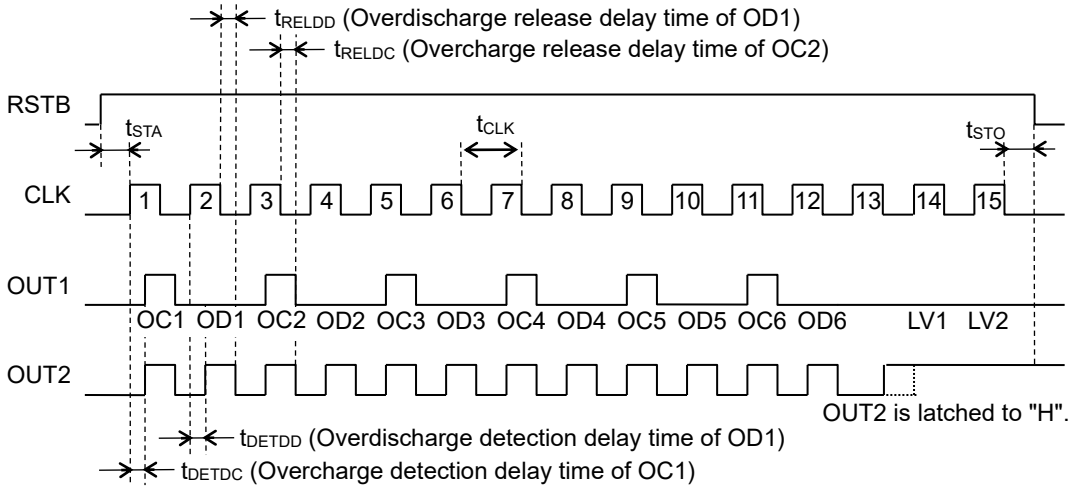


Figure 36

(2) Without self-test result output latch

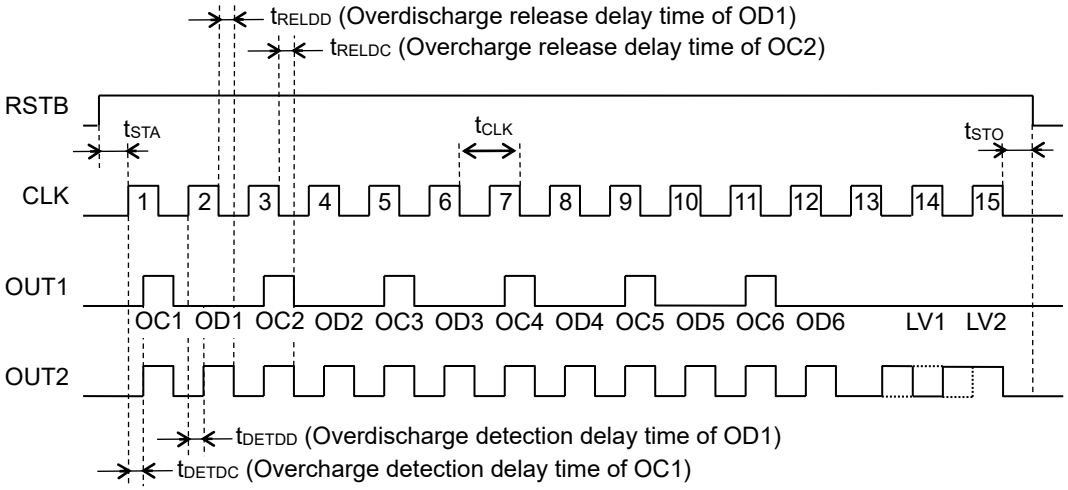


Figure 37

Downloaded from Arrow.com.

■ Precautions

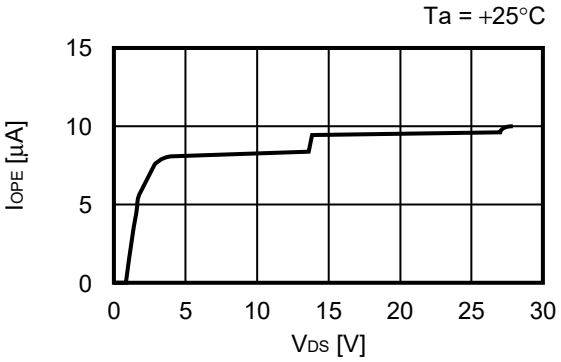
- The application conditions for the input voltage, output voltage, and load current should not exceed the power dissipation.
- Batteries can be connected in any order; however, there may be cases when the OUT2 pin output is in the detection status after batteries are connected. In this case, the S-19192 Series returns to the normal status when inputting "H" to the RSTB pin and returning the input voltage to "L".
- Do not apply an electrostatic discharge to this IC that exceeds the performance ratings of the built-in electrostatic protection circuit.
- ABLIC Inc. claims no responsibility for any disputes arising out of or in connection with any infringement by products including this IC of patents owned by a third party.

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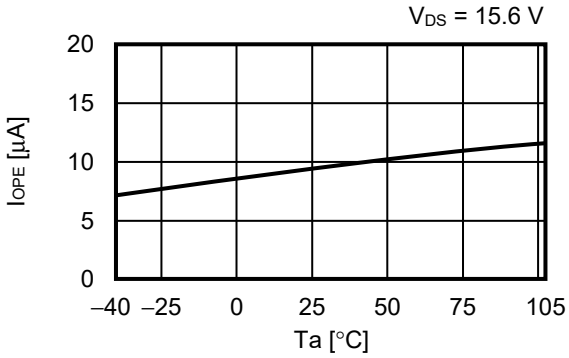
■ Characteristics (Typical Data)

1. Current consumption

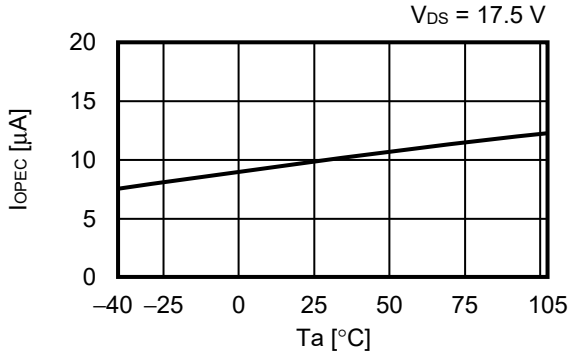
1. 1 I_{OPE} vs. V_{DS}



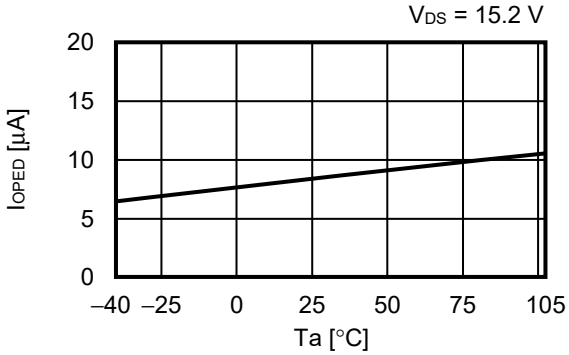
1. 2 I_{OPE} vs. Ta



1. 3 I_{OPEC} vs. Ta



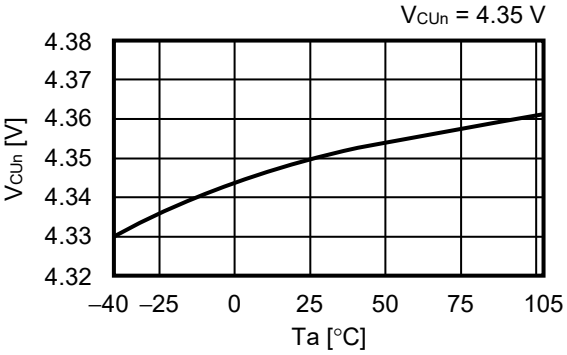
1. 4 I_{OPED} vs. Ta



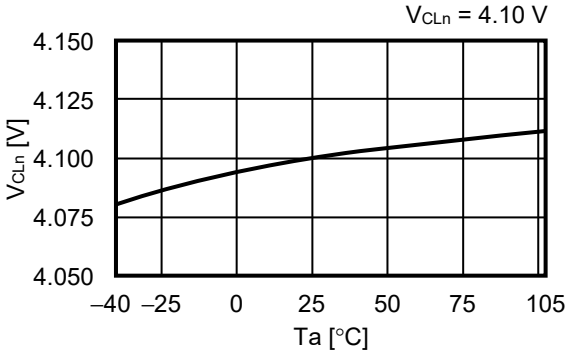
Downloaded from Arrow.com.

2. Detection voltage, release voltage

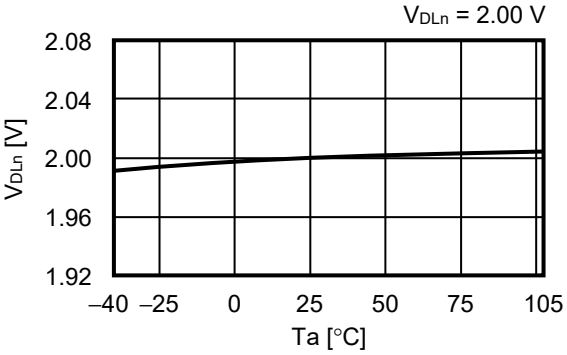
2. 1 V_{CUn} vs. Ta



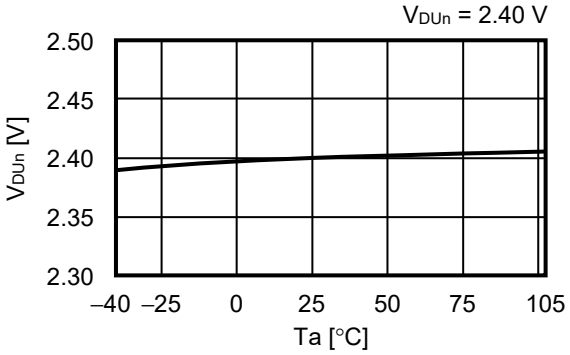
2. 2 V_{CLn} vs. Ta



2. 3 V_{DLn} vs. Ta

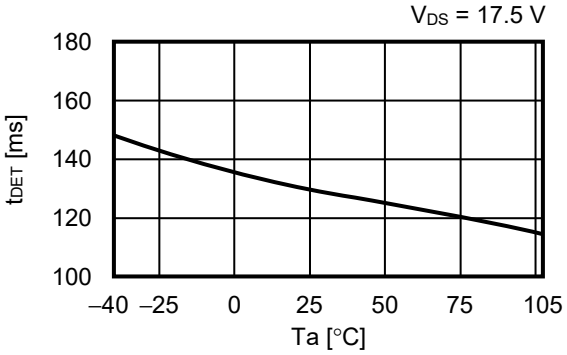


2. 4 V_{DUn} vs. Ta

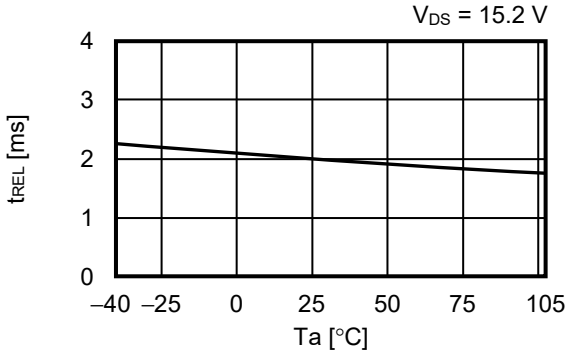


3. Delay time

3. 1 t_{DET} vs. Ta



3. 2 t_{REL} vs. Ta

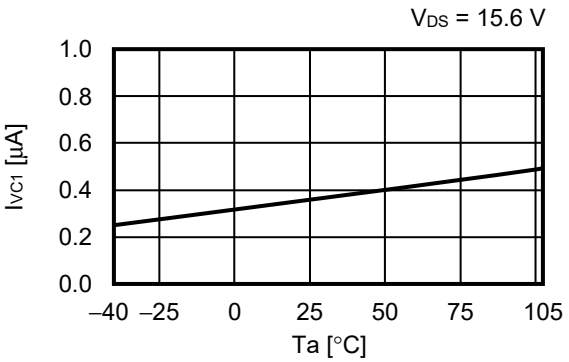


Remark n = 1 to 6

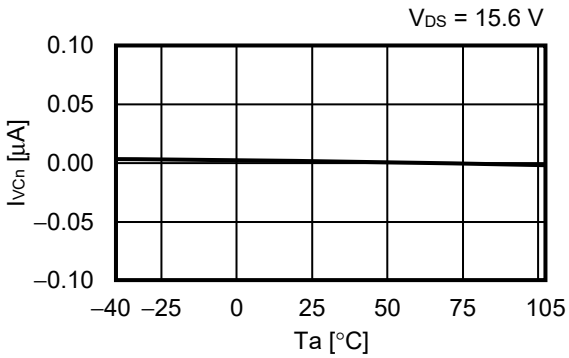
Downloaded from Arrow.com.

4. Input current

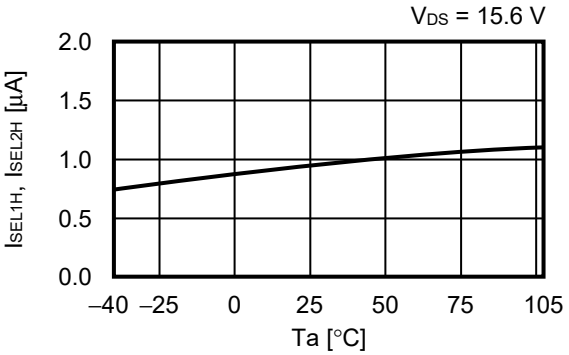
4. 1 I_{VC1} vs. Ta



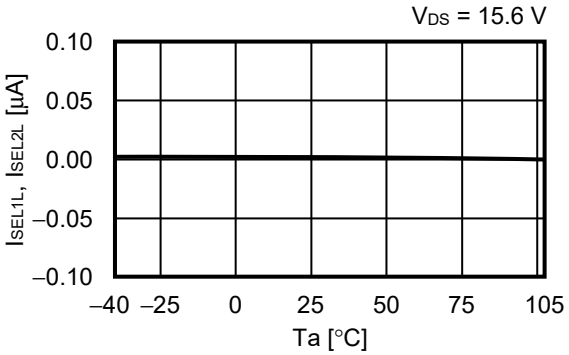
4. 2 I_{VCn} vs. Ta



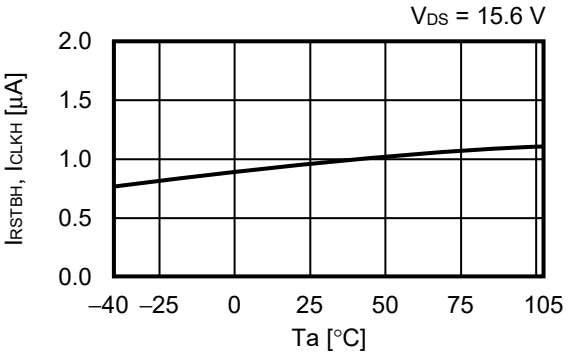
4. 3 I_{SEL1H}, I_{SEL2H} vs. Ta



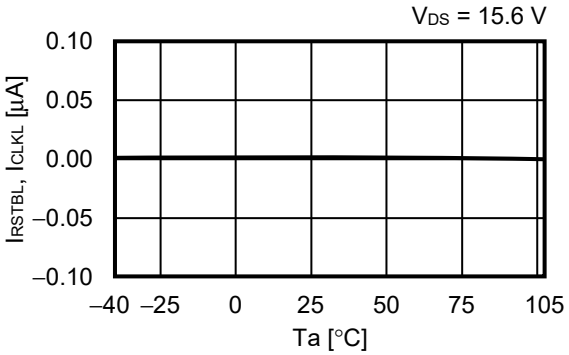
4. 4 I_{SEL1L}, I_{SEL2L} vs. Ta



4. 5 I_{RSTBH}, I_{CLKH} vs. Ta



4. 6 I_{RSTBL}, I_{CLKL} vs. Ta

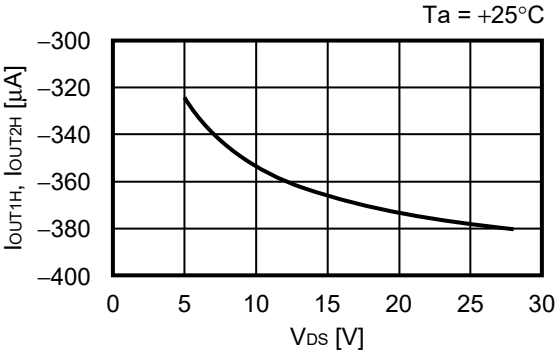


Remark n = 2 to 6

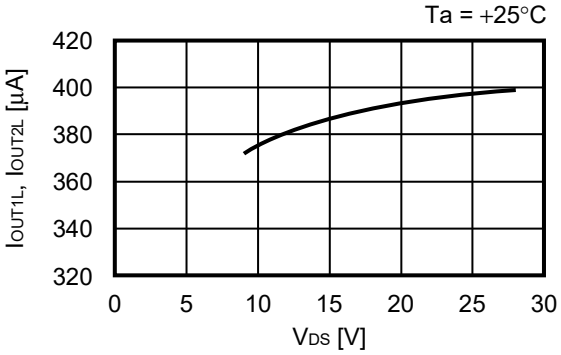
Downloaded from Arrow.com.

5. Output current

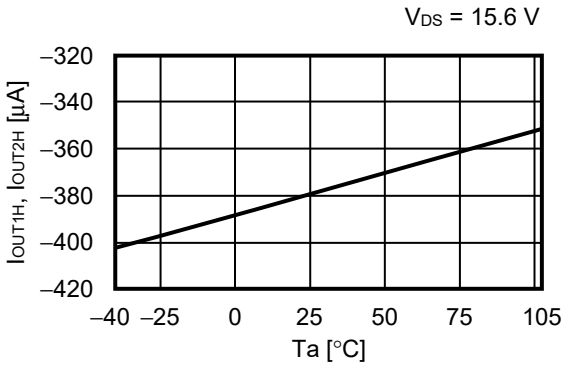
5. 1 I_{OUT1H}, I_{OUT2H} vs. V_{DS}



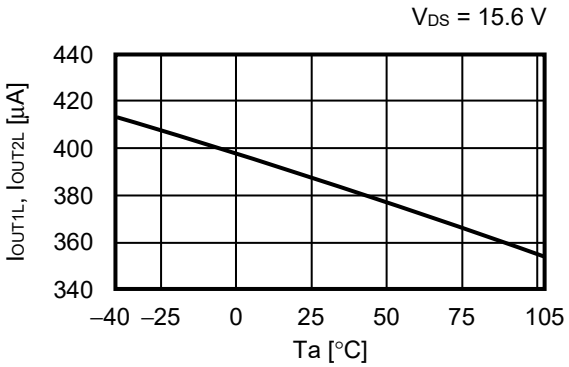
5. 2 I_{OUT1L}, I_{OUT2L} vs. V_{DS}



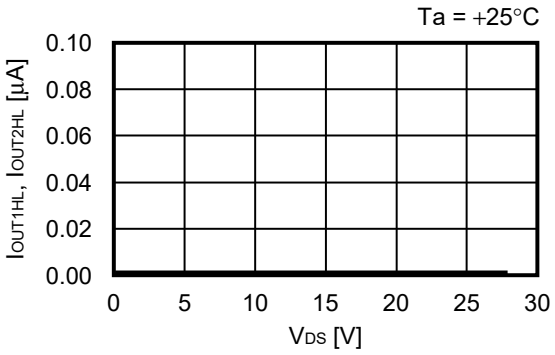
5. 3 I_{OUT1H}, I_{OUT2H} vs. Ta



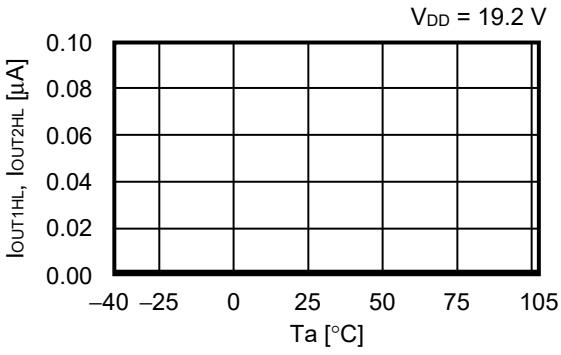
5. 4 I_{OUT1L}, I_{OUT2L} vs. Ta



5. 5 I_{OUT1HL}, I_{OUT2HL} vs. V_{DS}



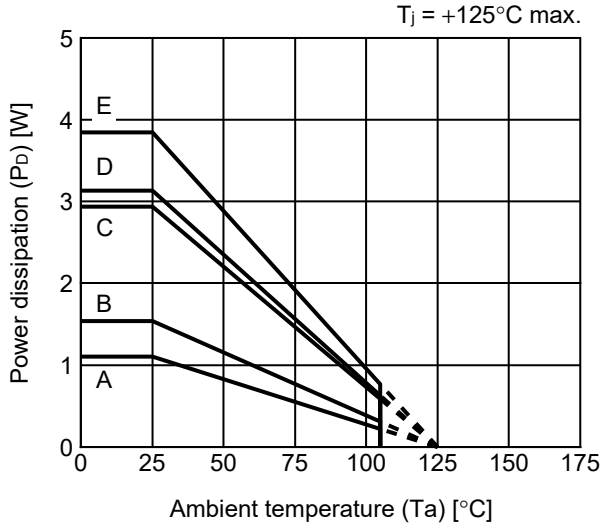
5. 6 I_{OUT1HL}, I_{OUT2HL} vs. Ta



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■ Power Dissipation

HTSSOP-16



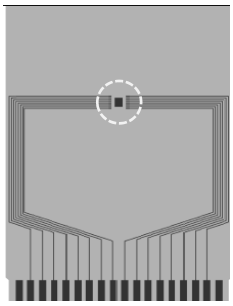
Board	Power Dissipation (P_D)
A	1.10 W
B	1.54 W
C	2.94 W
D	3.13 W
E	3.85 W

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HTSSOP-16 Test Board

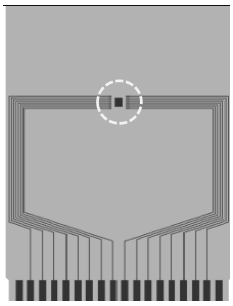
IC Mount Area

(1) Board A



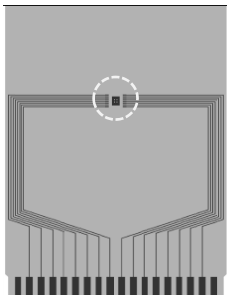
Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		2
Copper foil layer [mm]	1	Land pattern and wiring for testing: t0.070
	2	-
	3	-
	4	74.2 x 74.2 x t0.070
Thermal via		-

(2) Board B



Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		4
Copper foil layer [mm]	1	Land pattern and wiring for testing: t0.070
	2	74.2 x 74.2 x t0.035
	3	74.2 x 74.2 x t0.035
	4	74.2 x 74.2 x t0.070
Thermal via		-

(3) Board C



Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		4
Copper foil layer [mm]	1	Land pattern and wiring for testing: t0.070
	2	74.2 x 74.2 x t0.035
	3	74.2 x 74.2 x t0.035
	4	74.2 x 74.2 x t0.070
Thermal via		Number: 4 Diameter: 0.3 mm



enlarged view

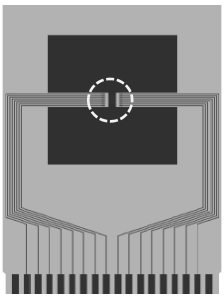
No. HTSSOP16-A-Board-SD-1.0

Downloaded from Arrow.com.

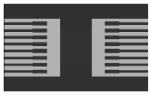
HTSSOP-16 Test Board

IC Mount Area

(4) Board D

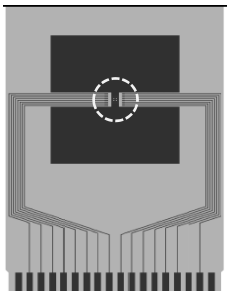


Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		4
Copper foil layer [mm]	1	Pattern for heat radiation: 2000mm^2 t0.070
	2	74.2 x 74.2 x t0.035
	3	74.2 x 74.2 x t0.035
	4	74.2 x 74.2 x t0.070
Thermal via		-



enlarged view

(5) Board E



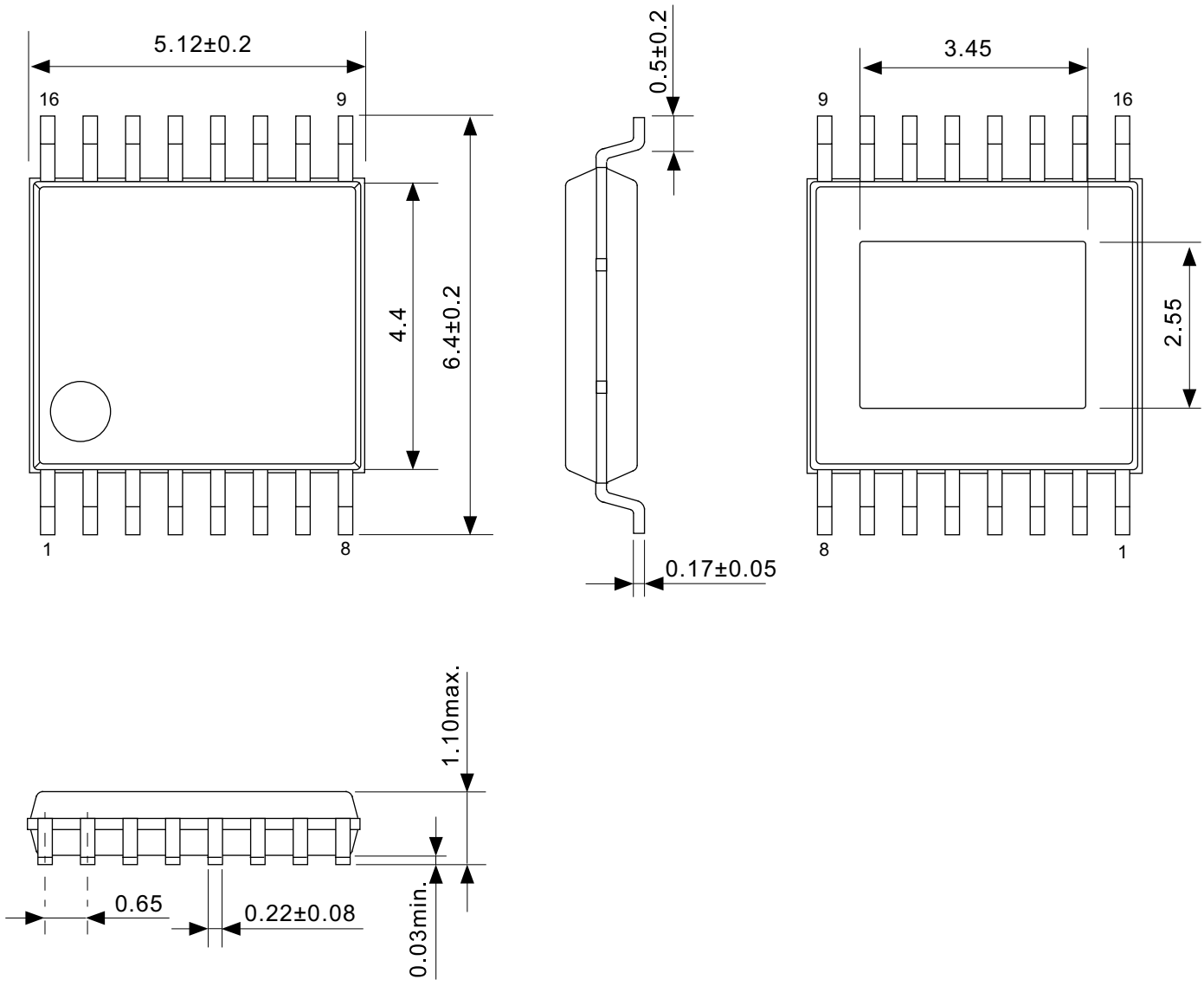
Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		4
Copper foil layer [mm]	1	Pattern for heat radiation: 2000mm^2 t0.070
	2	74.2 x 74.2 x t0.035
	3	74.2 x 74.2 x t0.035
	4	74.2 x 74.2 x t0.070
Thermal via		Number: 4 Diameter: 0.3 mm



enlarged view

No. HTSSOP16-A-Board-SD-1.0

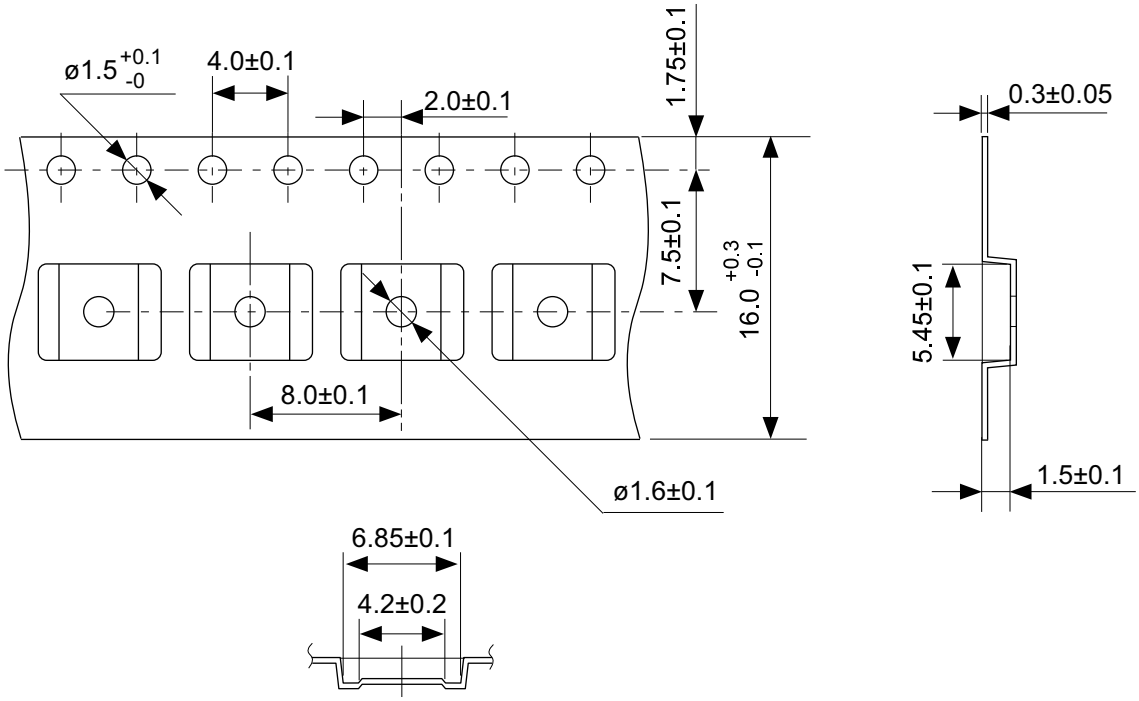
Downloaded from Arrow.com.

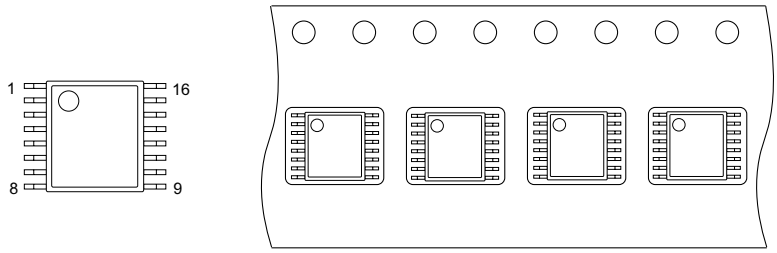


No. FR016-A-P-SD-1.0

TITLE	HTSSOP16-A-PKG Dimensions
No.	FR016-A-P-SD-1.0
ANGLE	
UNIT	mm
ABLIC Inc.	

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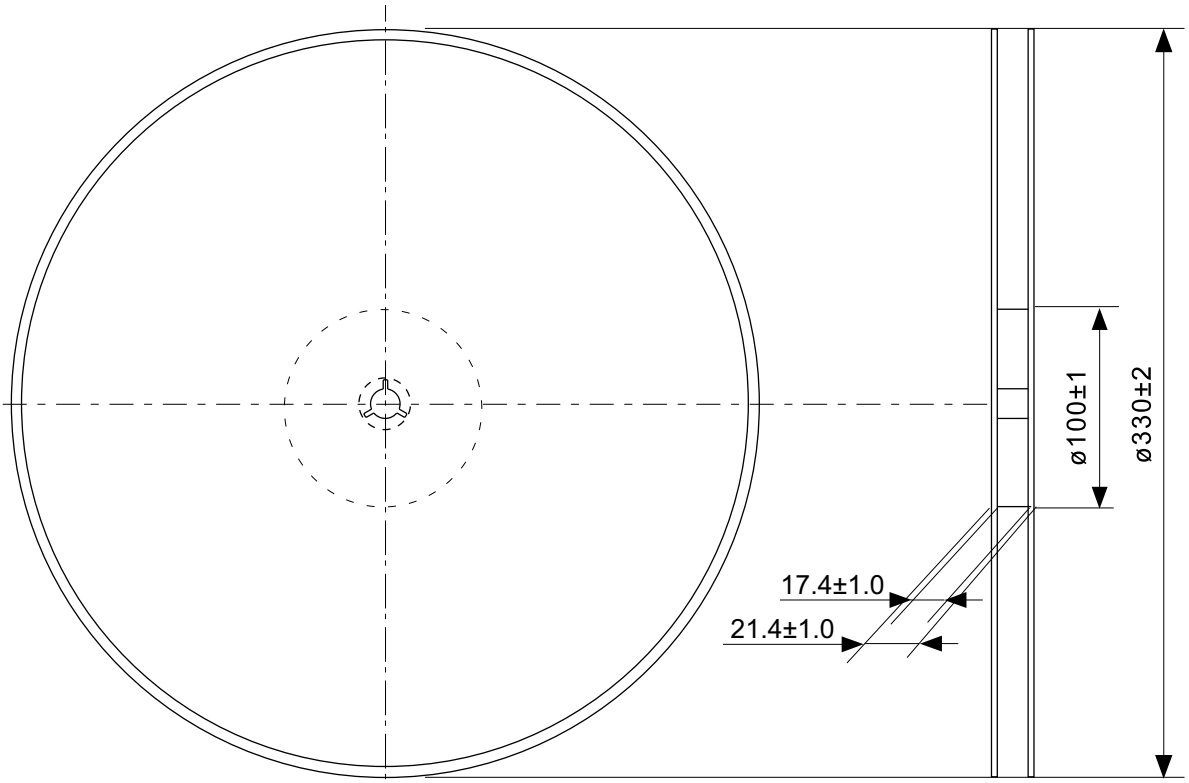




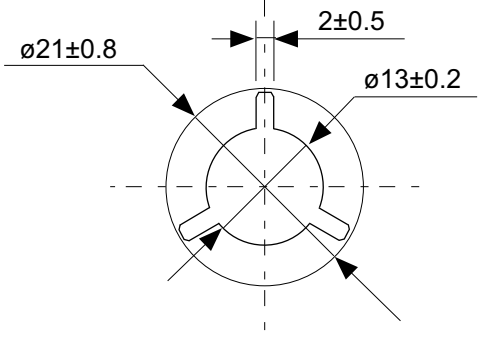
No. FR016-A-C-SD-1.0

TITLE	HTSSOP16-A-Carrier Tape
No.	FR016-A-C-SD-1.0
ANGLE	
UNIT	mm
ABLIC Inc.	

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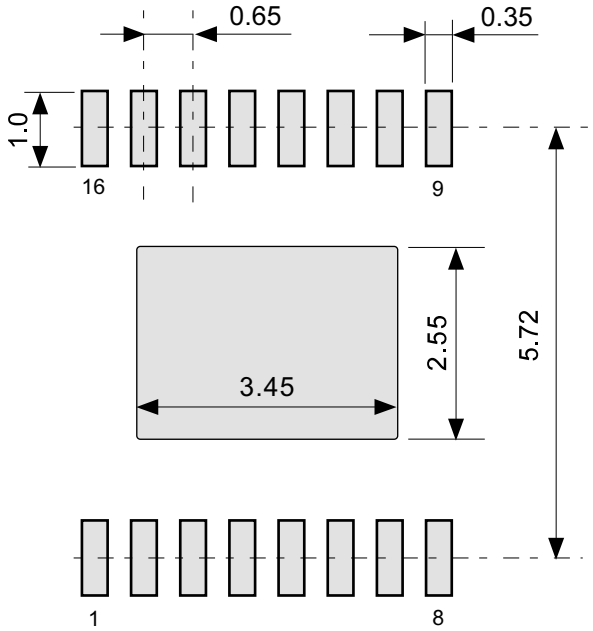
Enlarged drawing in the central part



No. FR016-A-R-SD-1.0

TITLE	HTSSOP16-A- Reel		
No.	FR016-A-R-SD-1.0		
ANGLE		QTY.	4,000
UNIT	mm		
ABLIC Inc.			

Downloaded from Arrow.com.



No. FR016-A-L-SD-1.0

TITLE	HTSSOP16-A -Land Recommendation
No.	FR016-A-L-SD-1.0
ANGLE	
UNIT	mm
ABLIC Inc.	

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   The entire system in which the products are used must be sufficiently evaluated and judged whether the products are allowed to apply for the system on customer's own responsibility.
10. The products are not designed to be radiation-proof. The necessary radiation measures should be taken in the product design by the customer depending on the intended use.
11. The products do not affect human health under normal use. However, they contain chemical substances and heavy metals and should therefore not be put in the mouth. The fracture surfaces of wafers and chips may be sharp. Be careful when handling these with the bare hands to prevent injuries, etc.
12. When disposing of the products, comply with the laws and ordinances of the country or region where they are used.
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