FS312 Series Datasheet〔V1.3N〕

Lithium Battery Protection IC

1. Description

FS312 is a series of lithium ion and lithium polymer rechargeable battery protection ICs with high accurate voltage detection and delay circuits.

These ICs are suitable for protection of single cell lithium ion or lithium polymer battery packs from over charge, over discharge, and over current.

2. 1-Cell Protection ICs

Model	Package	Overcharge detection voltage [VOCU] (V)	Overcharge release voltage [VOCR] (V)	Overdischarge detection voltage [VODL] (V)	Overdischarge release voltage [VODR] (V)	Overcurrent detection voltage [VOI1] (mV)
	SOT-23-6					
FS312	AR	4.250±0.025	4.050±0.05	2.4±0.08	3.0±0.08	200±30
	BR	4.350±0.025	4.150±0.05	2.4±0.08	3.0±0.08	200±30
	CR	4.250±0.025	4.050±0.05	2.4±0.08	3.0±0.08	150±30
	DR	4.350±0.025	4.150±0.05	2.4±0.08	3.0±0.08	150±30
	ER	4.280±0.025	3.980±0.05	2.3±0.08	3.1±0.08	125±30
	FR	4.250±0.025	4.050±0.05	2.9±0.08	3.0±0.08	150±30

Overcharge and overdischarge voltages and overcurrent detection voltage can be changed at the customer's request.

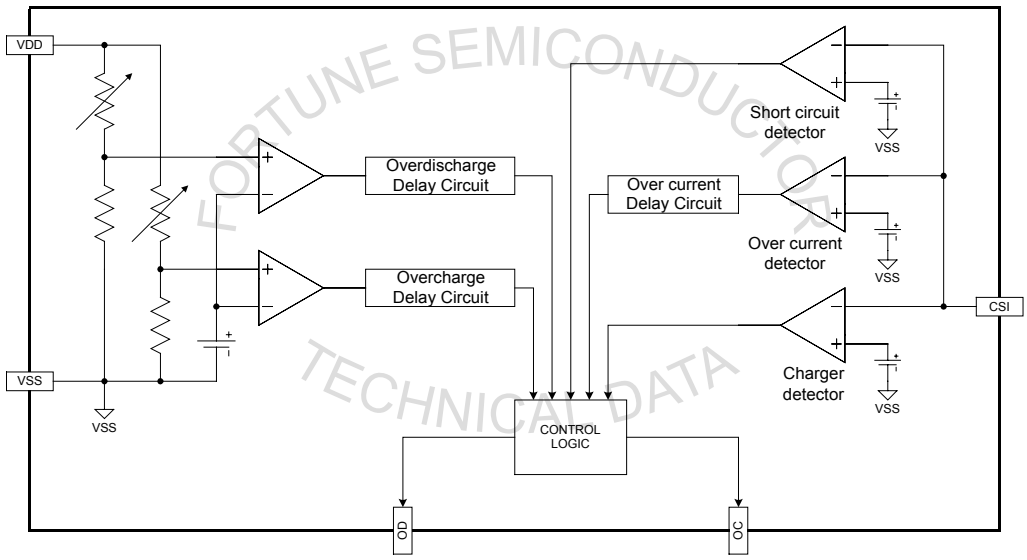
3. Features

1)	Low supply current	Operation: 3.0uA typ. @VDD=3.9V Power-down mode: 0.3uA typ. @VDD=2.0V
2)	Overcharge detection voltage〔VOCU〕	4.0V~4.4V, Accuracy of ±25mV
3)	Overcharge release voltage〔VOCR〕	VOCR, Accuracy of ±50mV
4)	Overdischarge detection voltage〔VODL〕	2.3V~2.5V, Accuracy of ±80mV
5)	Overdischarge release voltage〔VODR〕	VODR, Accuracy of ±80mV
6)	Over current detection voltage〔VOI1〕	VOI1
7)	Short circuit detection voltage〔VOI2〕	1.35V
8)	Delay times are generated by an internal circuit. (External capacitors are unnecessary.)	
9)	Charger detection voltage	-1.35V
10)	Reset resistance for Over current protection	>500KΩ
11)	Wide supply voltage range	1.5 ~ 9.0V
12)	Small package	SOT-23-6

4. Applications

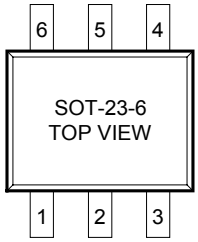
Protection IC for One-Cell Lithium-Ion / Lithium-Polymer Battery Pack

5. Block Diagram

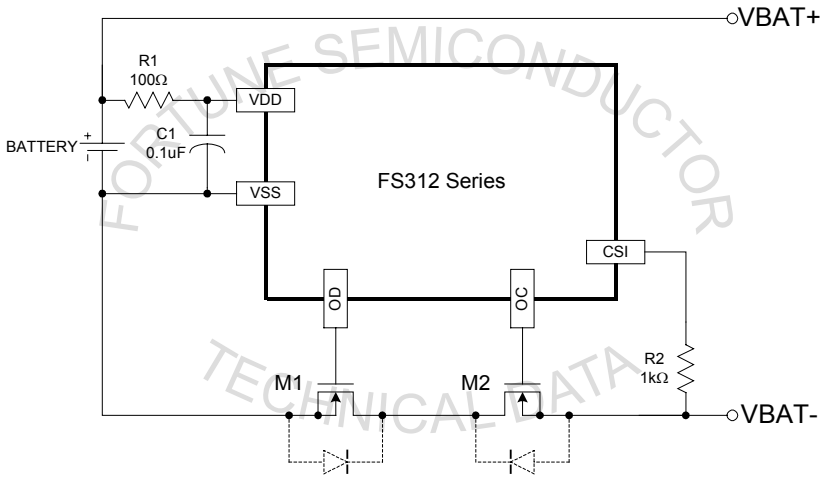


6. Pin Configuration

Pin No.	Symbol	Description
1	OD	FET gate connection pin for discharge control
2	CSI	Input pin for current sense, charger detect
3	OC	FET gate connection pin for charge control
4	NC	No Connecting
5	VDD	Positive power input pin
6	VSS	Negative power input pin



7. Typical Application Circuit



8. Absolute Maximum Ratings

(VSS=0V, Ta=25℃ unless otherwise specified)

Item	Symbol	Rating	Unit
Input voltage between VDD and VSS *	VDD	VSS-0.3 to VSS+12	V
OC output pin voltage	VOC	VDD-26 to VDD+0.3	V
OD output pin voltage	VOD	VSS-0.3 to VDD+0.3	V
CSI input pin voltage	VCSI	VDD-26 to VDD+0.3	V
Operating Temperature Range	TOP	-40 to +85	℃
Storage Temperature Range	TST	-40 to +125	℃

Note: This IC contains a circuit that protects it from static discharge, but take special care that no excessive static electricity or voltage which exceeds the limit of the protection circuit is applied to the IC.

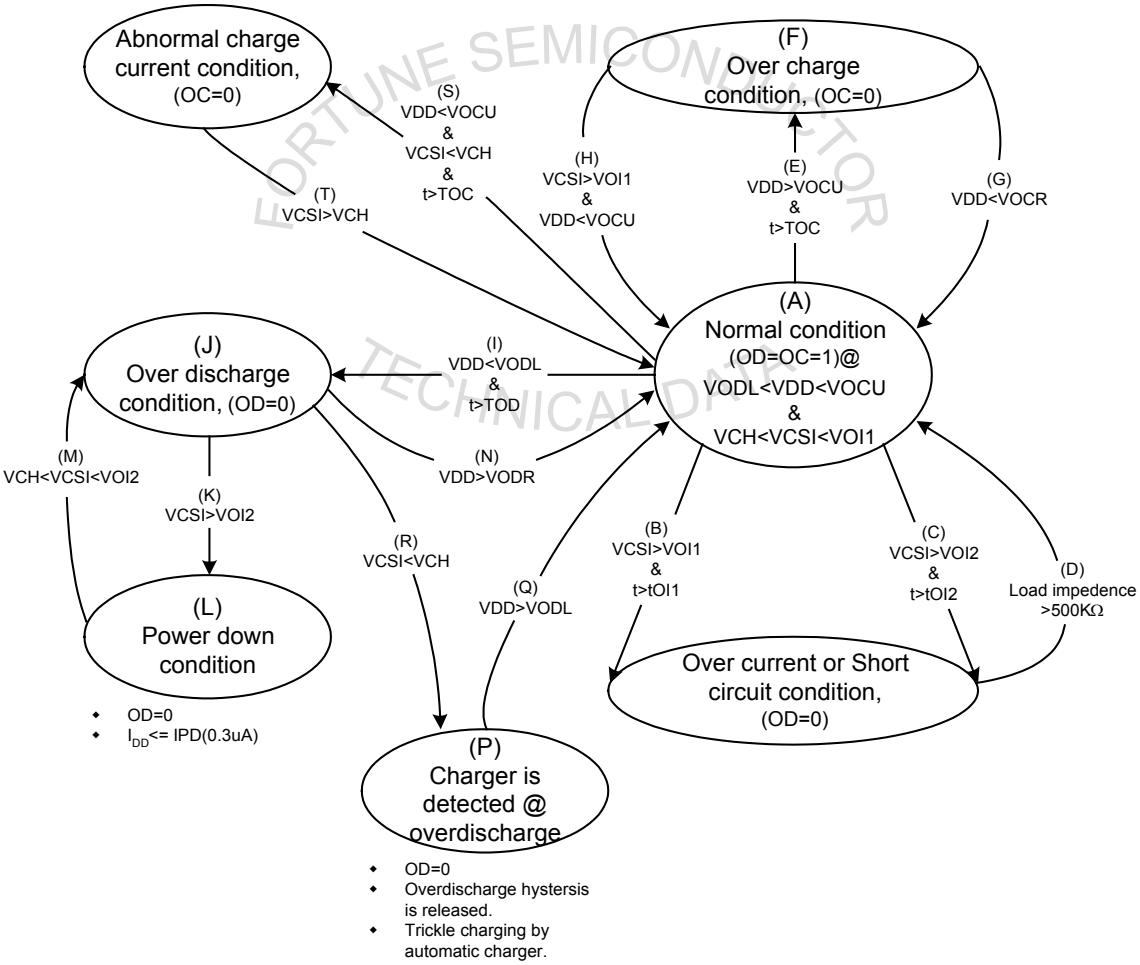
* Pulse (μ sec) noise exceeding the above input voltage (VSS+12V) may cause damage to the IC.

9. Electrical Characteristic

(VSS=0V, Ta=25℃ unless otherwise specified)

PARAMETER	CONDITIONS	SYMBOL	MIN.	TYP.	MAX.	UNIT
CURRENT CONSUMPTION						
Supply Current	VDD=3.9V	IDD		3.0	6.0	uA
Power-Down Current	VDD=2.0V	IPD		0.3	0.6	uA
OPERATING VOLTAGE						
Operating input voltage	VDD-VSS	VDS1	1.5		9.0	V
DETECTION VOLTAGE						
Overcharge detection voltage		VOCU	VOCU -0.025	VOCU	VOCU +0.025	V
Overcharge release voltage		VOCR	VOCR -0.050	VOCR	VOCR +0.050	V
Overdischarge detection voltage		VODL	VODL -0.080	VODL	VODL +0.080	V
Overdischarge release voltage		VODR	VODR -0.080	VODR	VODR +0.080	V
Over current detection voltage		VOI1	VOI1 -0.030	VOI1	VOI1 +0.030	V
Short circuit detection voltage	VDD=3.0V	VOI2	1.0	1.35	1.7	V
Reset resistance for Over current protection	VDD=3.6V	Rshort	400	500	600	KΩ
Charger detection voltage		VCH	-1.7	-1.35	-1.0	V
DELAY TIME						
Overcharge detection delay time	VDD=3.6V to 4.4V	TOC	50	100	150	ms
Overdischarge detection delay time	VDD=VODL+0.2V to VODL-0.2V	TOD	5	17	30	ms
Over current detection delay time	VDD=3.0V	TOI1	2	5	10	ms
Short circuit detection delay time	VDD=3.0V	TOI2		10	50	us
OTHER						
OC pin output “H” voltage	VDD=3.9V, Ioh=-50uA	Voh1	3.4	3.7		V
OC pin output “L” voltage	VDD=4.4V, CSI=0V	Vol1		0.1	0.5	V
OD pin output “H” voltage	VDD=3.9V, Ioh=-50uA	Voh2	3.4	3.7		V
OD pin output “L” voltage	VDD=2.2V, Iol=50uA	Vol2		0.1	0.5	V

10. State Diagram of Operation



11. Description of Operation

11.1 Normal Condition

If VODL<VDD<VOCU and VCH<VCSI<VOI1, M1 and M2 are both turned on. The charging and discharging processes can be operated normally.

11.2 Overcharge Detection

If the battery voltage detected from VDD reaches a certain value, charging from a charger is inhibited for overcharge protection. When VDD is larger than VOCU over a delay time of TOC, M2 is to be turned off.

11.3 Release of Overcharge Condition

There are two ways to return to normal condition from overcharge condition.

1) If the battery is self discharging and VDD<VOCR occurs, M2 is to be turned on and back to normal condition.
2) Remove the charger and connected to a load. If VOCR<VDD<VOCU and VCSI>VOI1 occurs, M2 is to be turned on and back to normal condition.

11.4 Overdischarge Detection

If the battery voltage detected from VDD is lower to a certain value, discharge to a load stops. VDD is smaller than VODL over a delay time of TOD, M1 is to be turned off. In the meanwhile, CSI is pulled to VDD by way of internal resistance, RCSID. If VCSI>VOI2, the protection IC enters into Power-down mode. (Its current consumption is lower than 0.3uA).

11.5 Release of Power-down mode

A charger is connected while the battery remains in Power-down mode. If VCH<VCSI<VOI2 and VDD<VODR occur, M1 is still off but it releases Power-down mode. If VDD>VODR occurs, M1 is to be turned on and back to normal condition.

11.6 Charger Detection

If a charger is connected to the battery remained in Power-down mode, the voltages will become VCSI<VCH and VDD>VODL. M1 is to be turned on and back to normal condition.

11.7 Abnormal Charging Condition

If a charger is connected to the battery in normal condition, VCSI<VCH occurs for a delay time longer than TOC, M2 is to be turned off.

11.8 Over current / Short circuit Detection

When the discharging current is too large during discharging under normal condition and the voltage detected from CSI is larger than VOIX (VOI1 or VOI2) for over a certain delay time TOIX (TOI1 or TOI2), it means the over current/short circuit condition occurred. M1 is turned off. CSI is pulled to VSS by way of an internal resistance, RCSIS.

- **If the over current / short circuit is detected and it continues for longer than the overdischarge detection delay time without releasing the load, the condition changes to the power-down condition when the battery voltage falls below the overdischarge detection voltage.**

- **If the battery voltage falls below the overdischarge detection voltage due to the over current / short circuit, the discharging control FET turns off when the over current / short circuit is detected. If the battery voltage restores late and the battery voltage after the overdischarge detection delay time is equal to or lower than the overdischarge detection voltage, the condition changes to the power-down condition.**

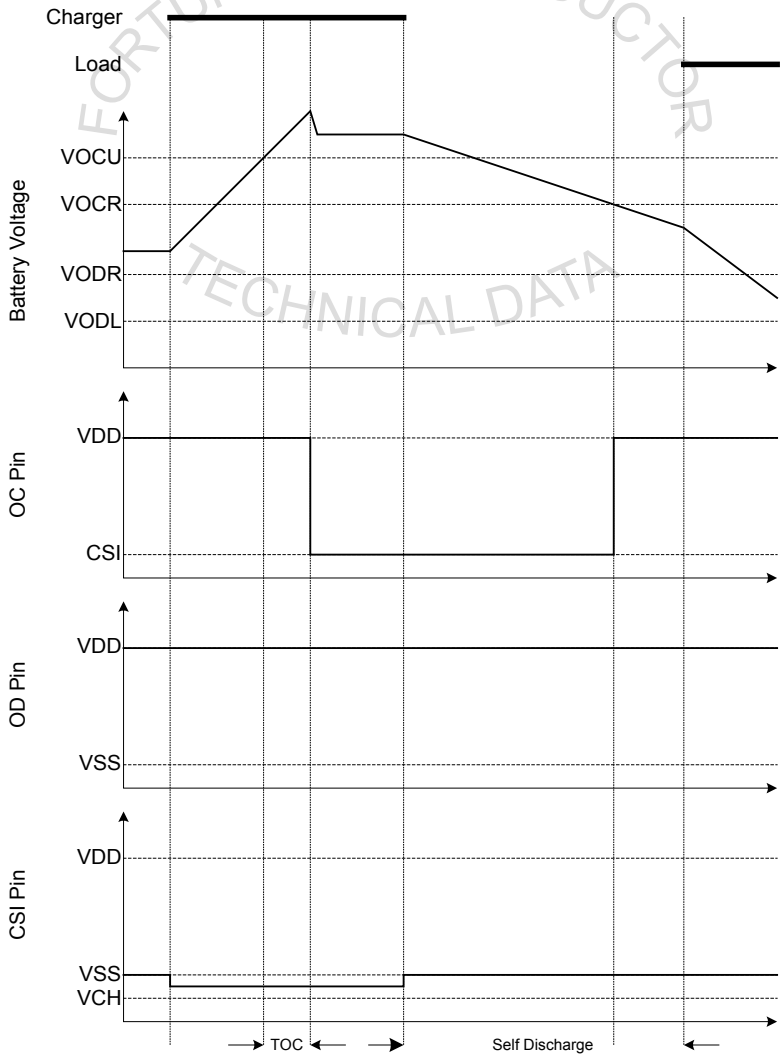
11.9 Release of Over current / Short circuit Condition

While the protection IC remains in Over current/Short circuit condition and load is removed or the impedance between VBAT+ and VBAT- is larger than 500KΩ and VCSI<VOI1, M1 is to be turned on and back to normal condition.

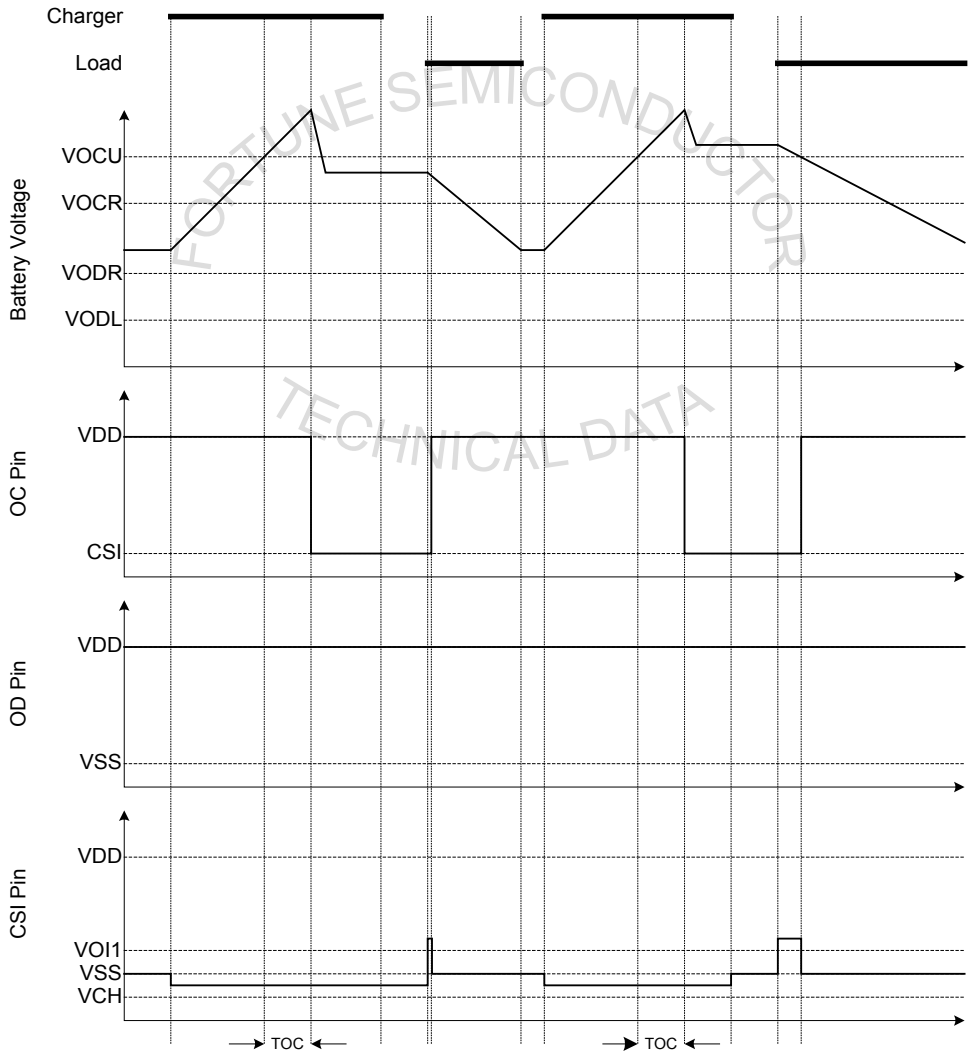
Note : When a battery is connected to an IC for the first time, the IC may not enter the normal condition (not dischargeable condition). If this occurs, set the CSI pin voltage equal to the VSS voltage (short the CSI and VSS pins or connect a charger) to enter the normal condition.

12. Timing Diagram

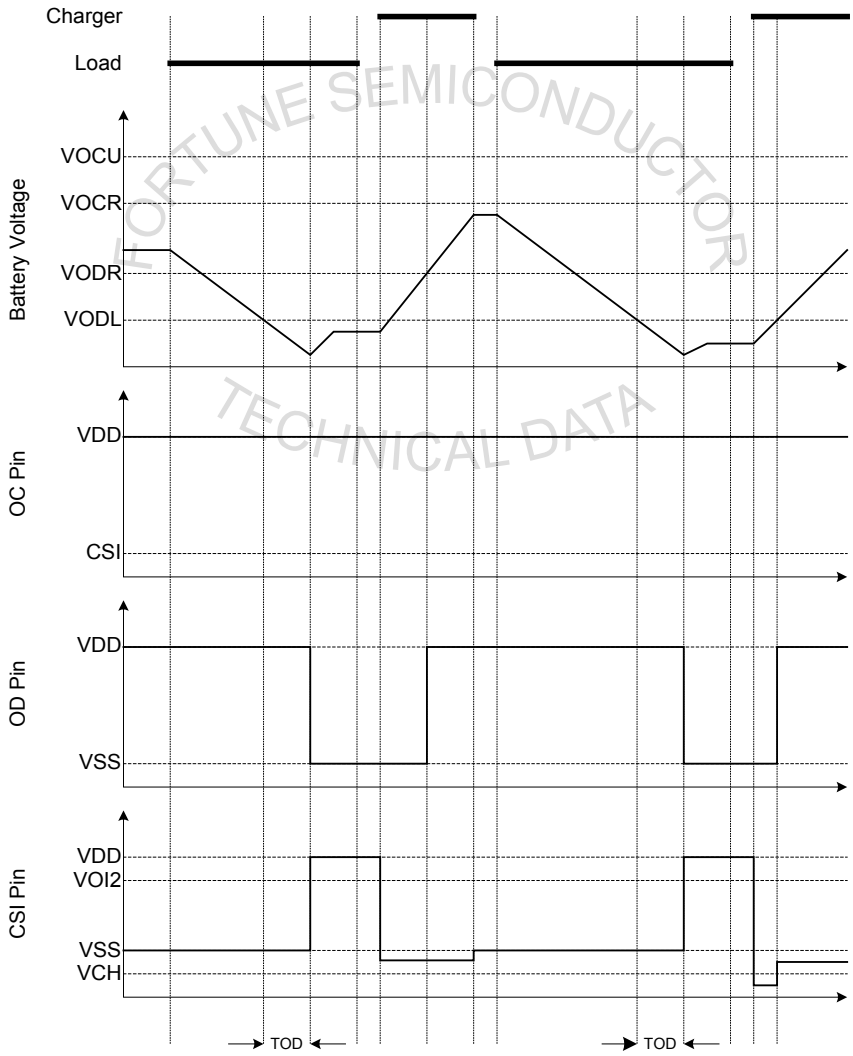
12.1 Overcharge Condition →Self Discharging → Normal Condition



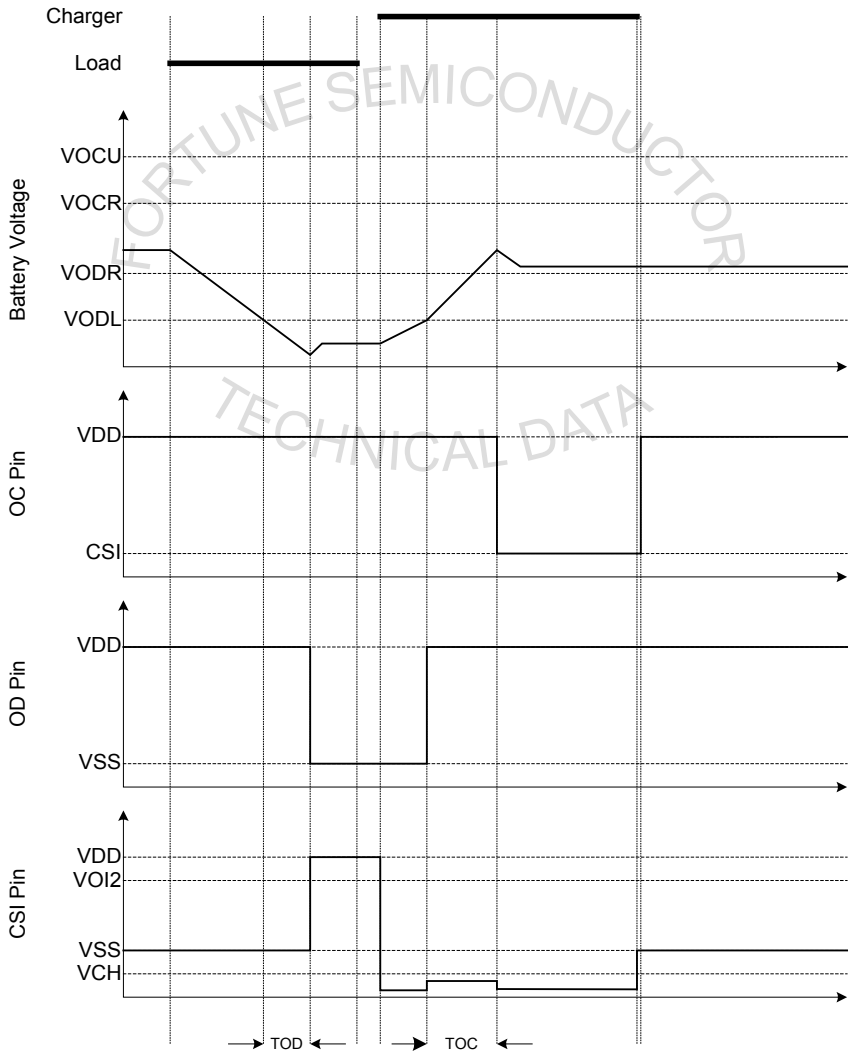
12.2 Overcharge Condition →Load Discharging → Normal Condition



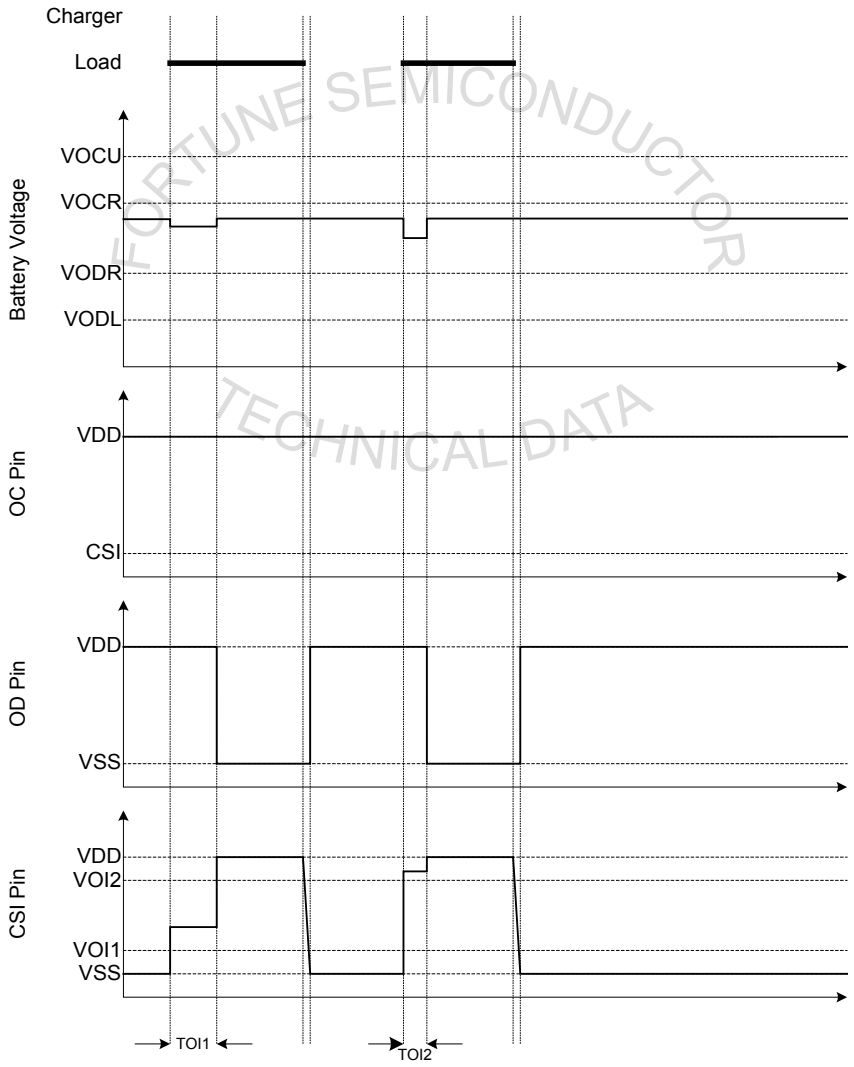
12.3 Overdischarge Condition → Charging by a Charger →Normal Condition



12.4 Overdischarge Condition → Abnormal Charging →Normal Condition

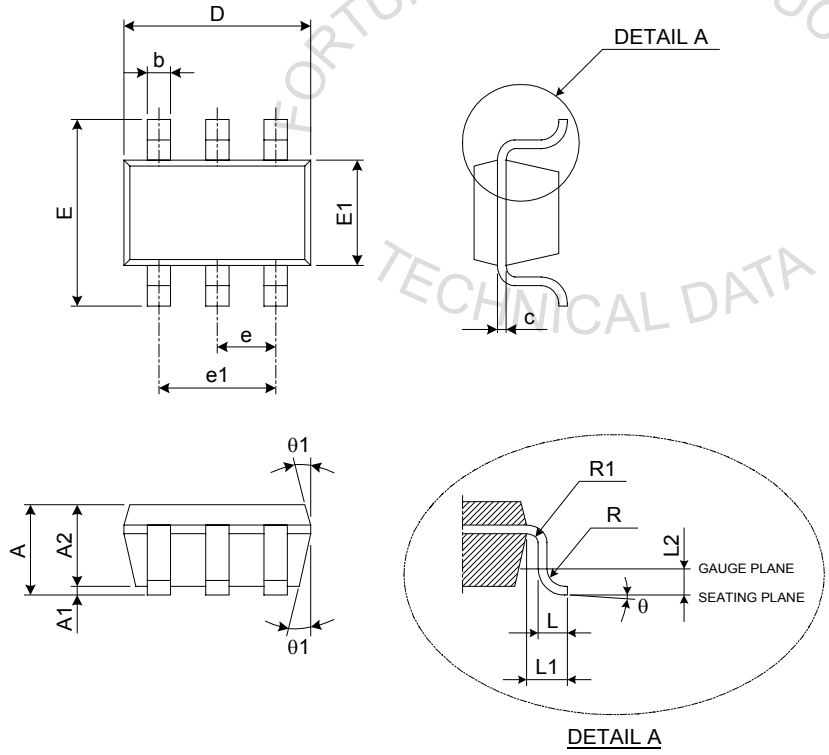


12.5 Over current / Short circuit Condition → Normal Condition



13. SOT-23-6

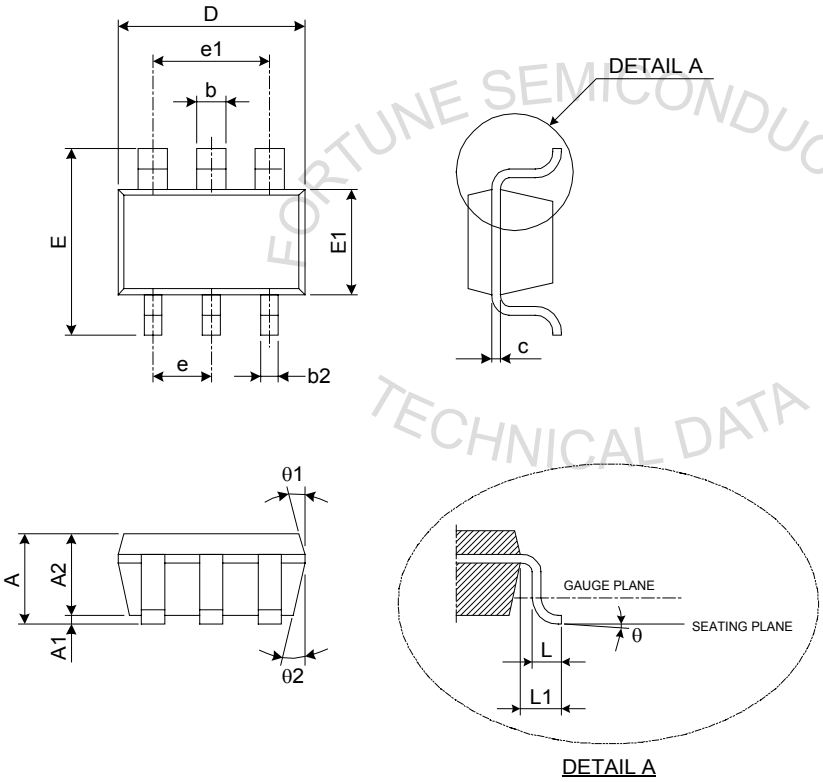
13.1 Dimensions (Package A)



Unit : mm

SYMBOL	MIN.	TYP.	MAX.
A	-	-	1.45
A1	-	-	0.15
A2	0.90	1.15	1.30
b	0.30	-	0.50
c	0.08	-	0.22
D		2.90 BSC.	
E		2.80 BSC.	
E1		1.60 BSC.	
e		0.95 BSC.	
e1		1.90 BSC.	
L	0.30	0.45	0.60
L1		0.60 REF.	
L2		0.25 BSC.	
R	0.10	-	-
R1	0.10	-	0.25
θ	0°	4°	8°
θ1	5°	10°	15°

13.2 Dimensions (Package B)



Unit : mm

SYMBOL	MIN.	TYP.	MAX.
A	1.05	-	1.35
A1	0.05	-	0.15
A2	1.00	1.10	1.20
b	0.40	-	0.55
b2	0.25	-	0.40
c	0.08	-	0.20
D	2.70	2.90	3.00
E	2.60	2.80	3.00
E1	1.50	1.60	1.70
L	0.35	0.45	0.55
L1	0.60 REF.		
e	0.95 BSC.		
e1	1.90 BSC.		
θ	0°	5°	10°
θ1	3°	5°	7°
θ2	6°	8°	10°