FS326 Series Datasheet〔V1.2〕

Lithium-Ion/Lithium-Polymer Battery Protection IC

1. Description

FS326 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					
FS326	A	4.325±0.025	4.075±0.05	2.50±0.08	2.90±0.08	100±30
	B	4.350±0.025	4.150±0.05	2.30±0.08	3.00±0.08	100±30
	C	4.325±0.025	4.075±0.05	2.50±0.08	2.90±0.08	150±30
	D	4.300±0.025	4.080±0.05	2.50±0.08	2.90±0.08	150±30
	E	4.300±0.040	4.080±0.05	2.50±0.08	2.90±0.08	150±30

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

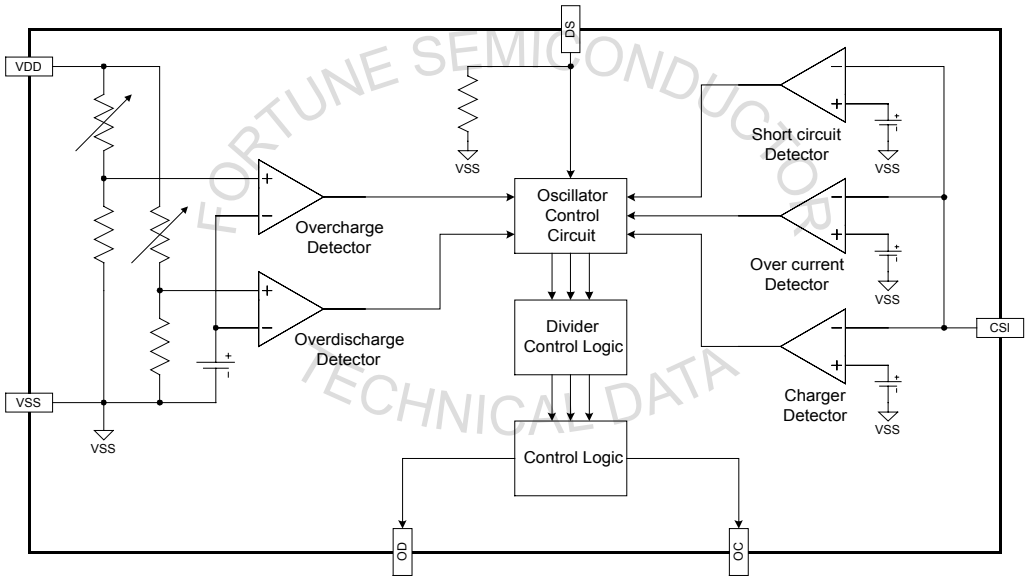
3. Features

1)	Low supply current	Operation: 3.0uA typ. @VDD=3.9V Power-down mode: 0.1uA max. @VDD=2.0V
2)	Overcharge detection voltage〔VOCU〕	4.0V~4.4V, Accuracy of ±25mV
3)	Overcharge release voltage〔VOCR〕	3.8V~4.4V, Accuracy of ±50mV
4)	Overdischarge detection voltage〔VODL〕	2.0V~3.0V, Accuracy of ±80mV
5)	Overdischarge release voltage〔VODR〕	2.0V~3.4V, Accuracy of ±80mV
6)	Over current detection voltage〔VOI1〕	0.05V~0.4V, Accuracy of ±30mV
7)	Short circuit detection voltage〔VOI2〕	Fixed at 1.35V
8)	Delay times are generated by an internal circuit. (External capacitors are unnecessary.)	
9)	Charger detection voltage	-0.5V
10)	Reset resistance for Over current protection	>500KΩ
11)	Wide supply voltage range	1.8 ~ 9.0V
12)	Small package	SOT-23-6

4. Applications

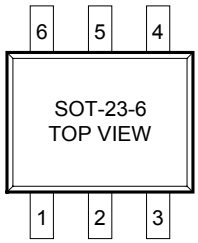
1) Protection IC for One-Cell Lithium-Ion / Lithium-Polymer Battery Pack

5. Block Diagram

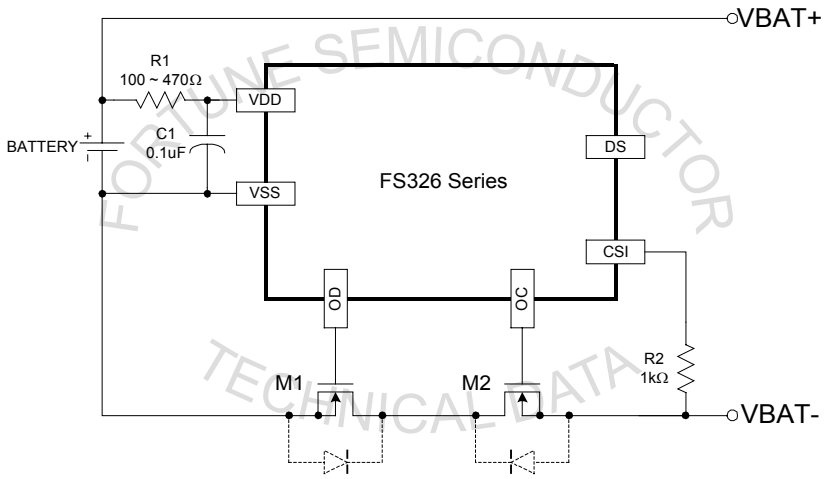


6. Pin Configuration

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	DS	Test pin for reduce delay time
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
DS input pin voltage	VDS	VSS-0.3 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.

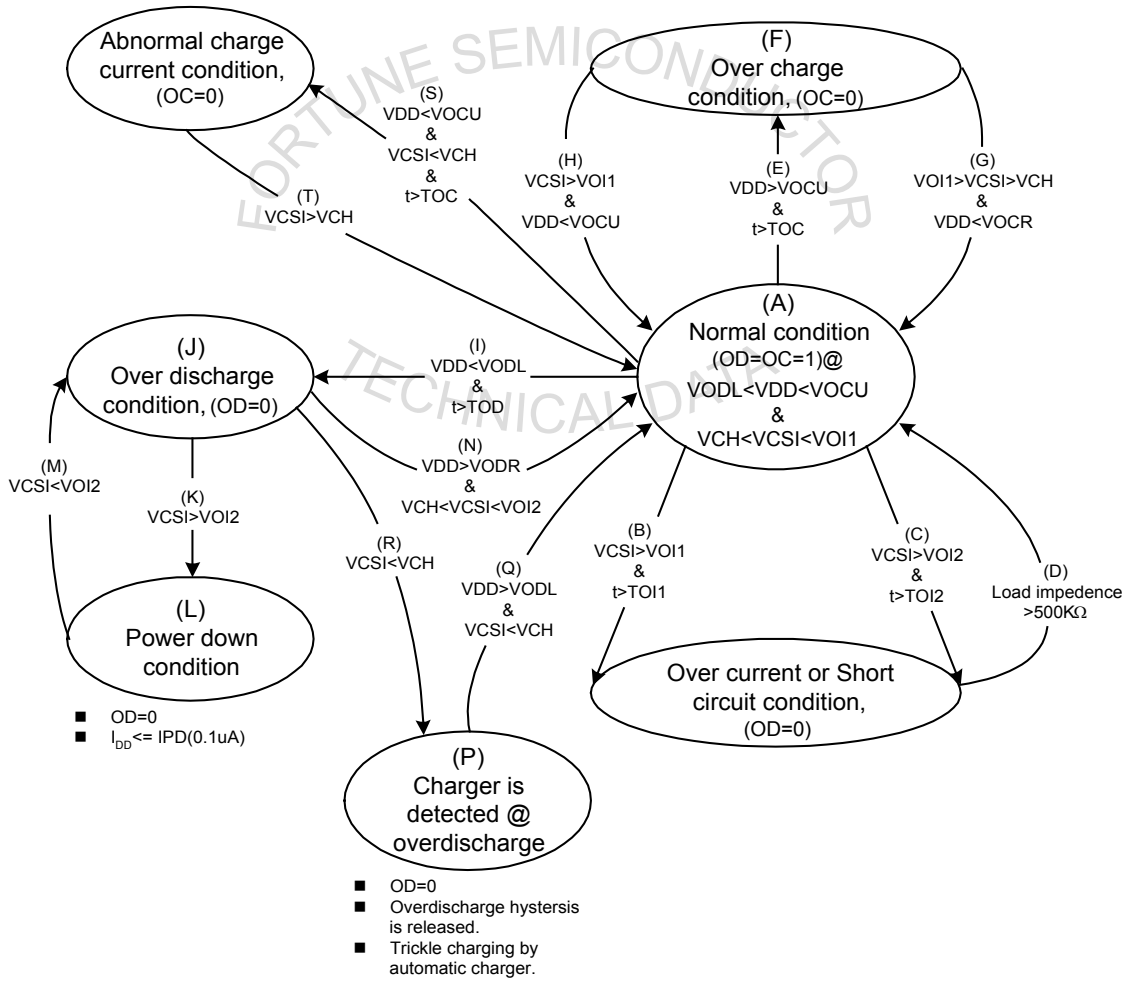
* Pulse (μ sec) noise exceeding the above input voltage (VSS+12V) may cause damage to the IC.

9. Electrical Characteristic

(VSS=0V, DS=Floating, 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			0.1	uA
OPERATING VOLTAGE						
Operating input voltage	VDD-VSS	VDS1	1.8		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	-1.2	-0.7	-0.2	V
DELAY TIME						
Overcharge detection delay time	VDD=3.6V to 4.4V	TOC		1.3	1.9	s
Overdischarge detection delay time	VDD=3.6V to 2.0V	TOD		180	260	ms
Over current detection delay time	VDD=3.0V	TOI1	5	10	15	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=4.5V, 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=2.0V, Iol=50uA	Vol2		0.1	0.5	V

10. State Diagram of Operation



11. Description of Operation

11.1 Normal Condition

The FS326 monitors the voltage of the battery connected between VDD and VSS pin and the voltage difference between CSI and VSS pin to control charging and discharging. When VODL<VDD<VOCU and VCH<VCSI<VOI1, the IC turns the charging(M2) and discharging(M1) control FETs on. The charging and discharging processes can be operated normally. This condition is called the normal condition.

- Note: When a battery is connected to the 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.

11.2 Overcharge Condition

When the battery voltage becomes higher than the overcharge detection voltage(VOCU) during charging under the normal condition and the detection continues for the overcharge detection delay time(TOC) or longer, the FS326 turns M2 off to stop charging. This condition is called the overcharge condition.

11.3 Release of Overcharge Condition

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

1) When the battery is self discharging, if VDD<VOCR and VOI1>VCSI>VCH occurs, M2 is to be turned on and back to normal condition.
2) Remove the charger and connected to a load, so that the discharging current flows through the parasitic diode in M2. At this moment VCSI increases momentarily Vf voltage of the parasitic diode from the VSS level. If VCSI>VOI1 and VDD<VOCU occurs, M2 is to be turned on and back to normal condition.

- Note 1: After entering the overcharge condition, if the charger is not removed and VOI1>VCSI>VCH, then M2 will be turned on when the voltage of the battery is lower than VOCR (because the self-discharge of the battery). The system can enter the charge status again as 1).
- Note 2: After entering the overcharge condition, if the charger is not removed and VCSI<VCH, then M2 will be kept off even though the voltage of the battery is lower than VOCR (because the self-discharge of the battery), and the system will not enter the charge status.

11.4 Overdischarge Condition

When the battery voltage falls below the overdischarge detection voltage(VODL) during discharging under the normal condition and the detection continues for the overdischarge detection delay time(TOD) or longer, the FS326 turns M1 off to stop discharging. This condition is called the

overdischarge condition. 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 0.1uA).

11.5 Release of Power-down mode

After entering Power-down mode, if the system is connected to a charger, and the charging current flows through the parasitic diode in M1. If VCSI<VOI2 occurs, then it will release Power-down mode. If keeping charging, there are two ways to enter the normal condition.

1) If VCSI<VCH (Charger detection), then when VDD>VODL, M1 will be turned on, and the system enters the normal condition.

2) If VCH<VCSI<VOI2, then it must be VDD>VODR for M1 to be turned on, and make the system enter the normal condition.

11.6 Charger Detection

In Power-down mode, when connecting to a charger, if VCSI<VCH, then M1 will be turned on when VDD>VODL, and the system will enter the normal condition as described in 1) of previous section, because the charger detection function is enabled. This action is called charger detection.

11.7 Abnormal Charge Current Condition

When a charger is connected to the battery in normal condition, if VDD<VOCU and VCSI<VCH occurs for a delay time longer than TOC, then M2 will be turned off and charging stop. This condition is called the abnormal charge current condition

Abnormal charge current condition is released when the voltage of CSI pin becomes higher than charger detection voltage(VCH), or the charger is removed.

11.8 Over Current / Short Circuit Condition

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. This condition is called the over current (short circuit) condition.

- **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.

11.10DS Pin

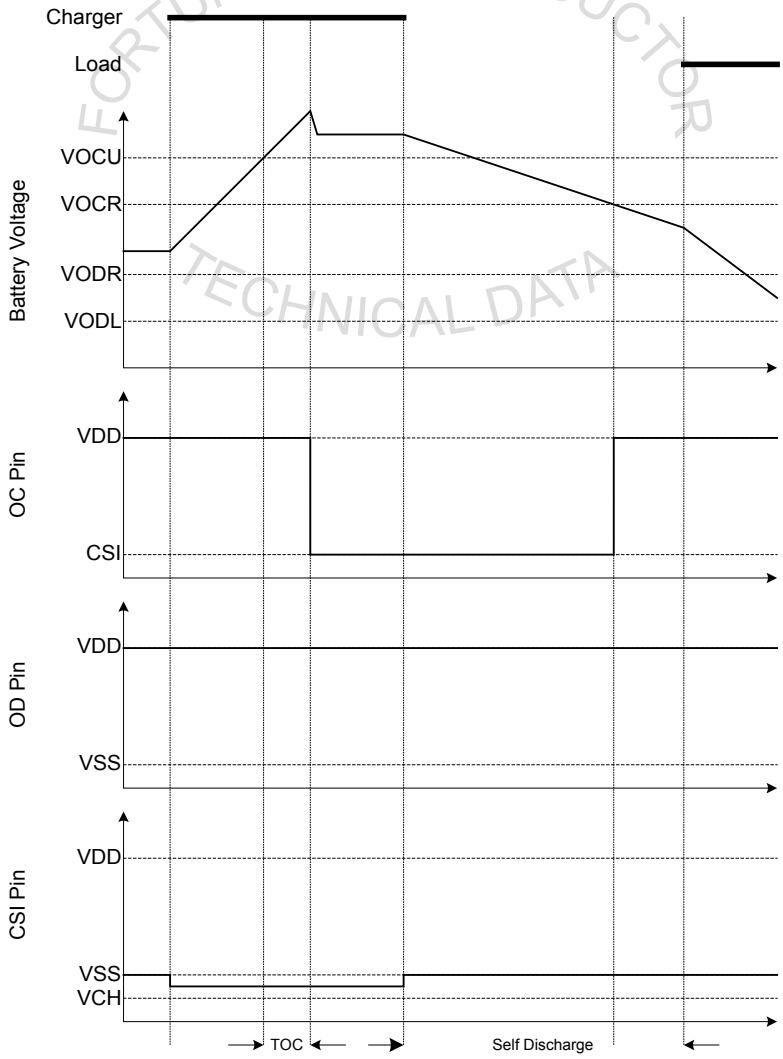
By forcing VDD voltage to DS pin, the delay time of overcharge and overdischarge can be reduced to within 50ms, therefore, testing time of protector circuit board can be reduced.

1.6MΩ pull down resistor is connected between DS pin and VSS internally.

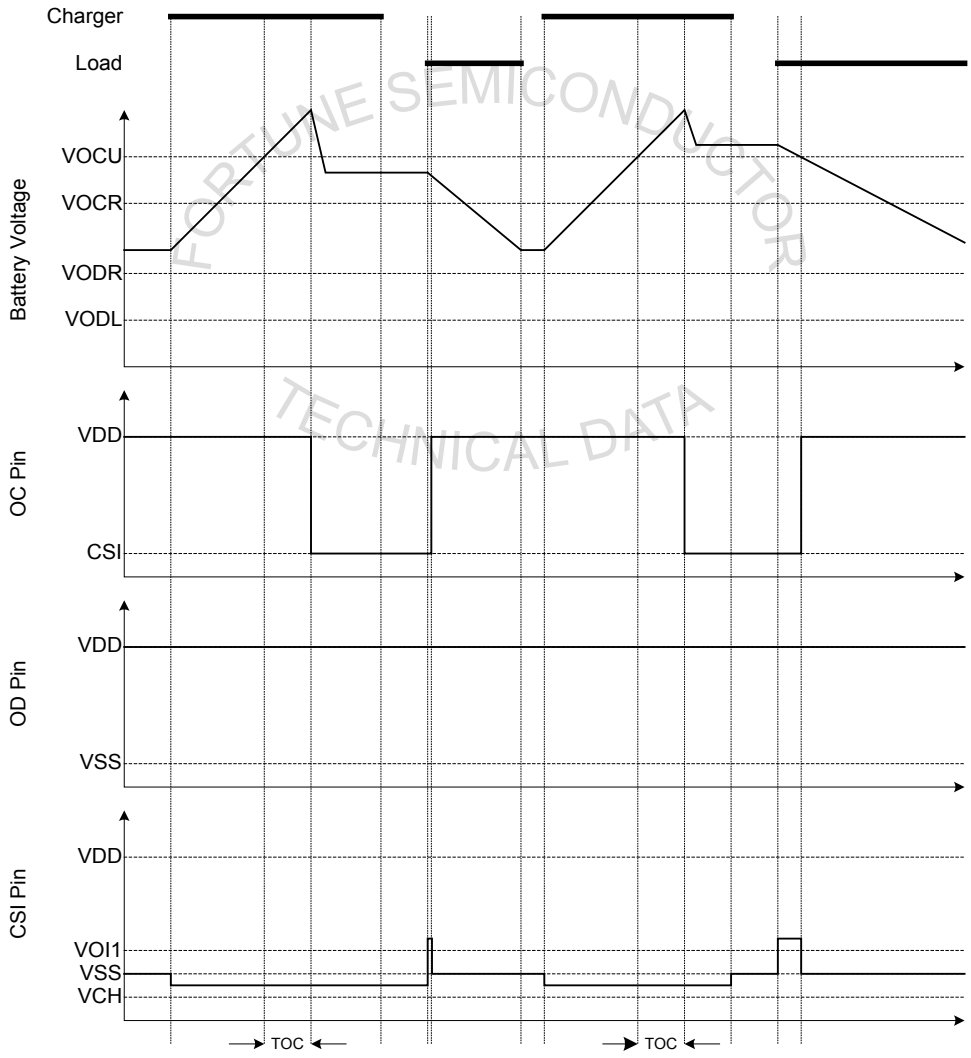
DS pin should be open, or connected to VSS in the actual application.

12. Timing Diagram

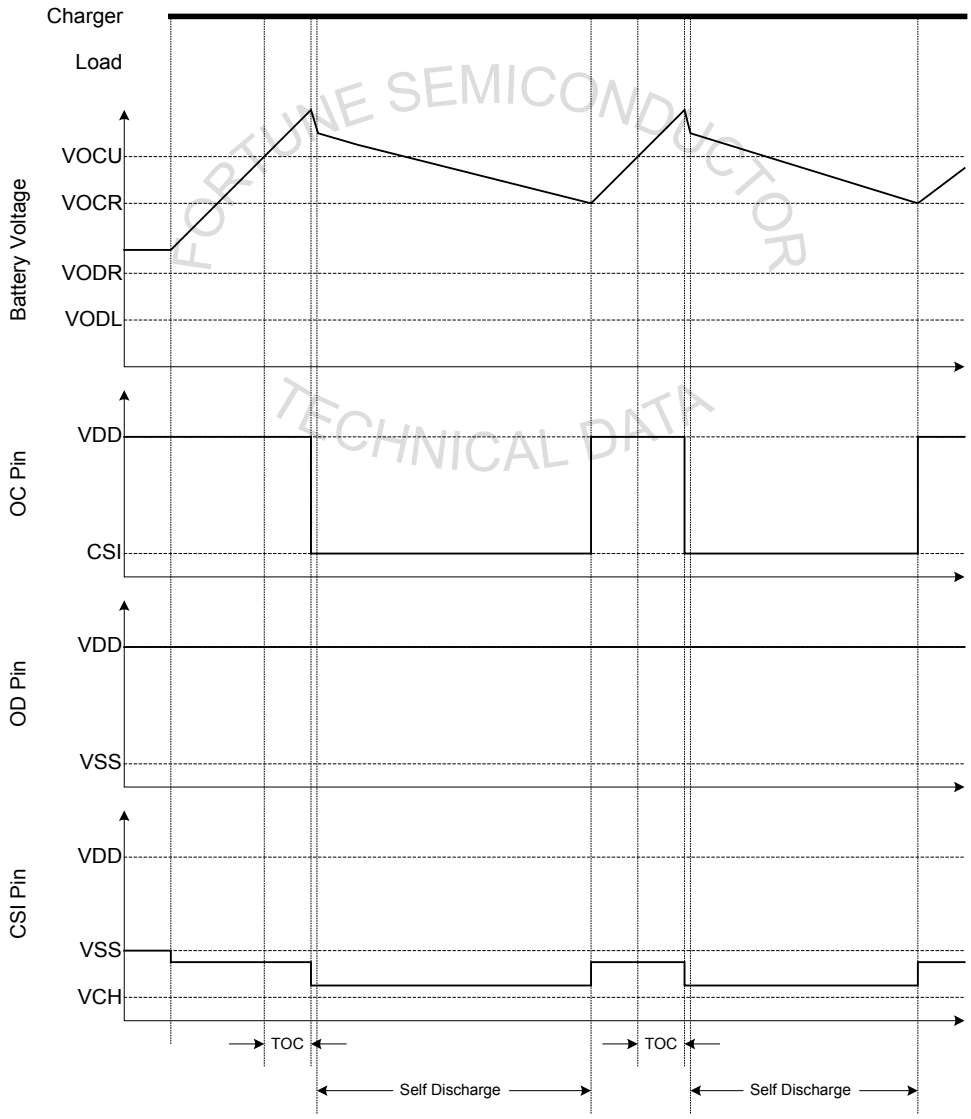
12.1 Overcharge Condition → Self Discharge → Normal Condition



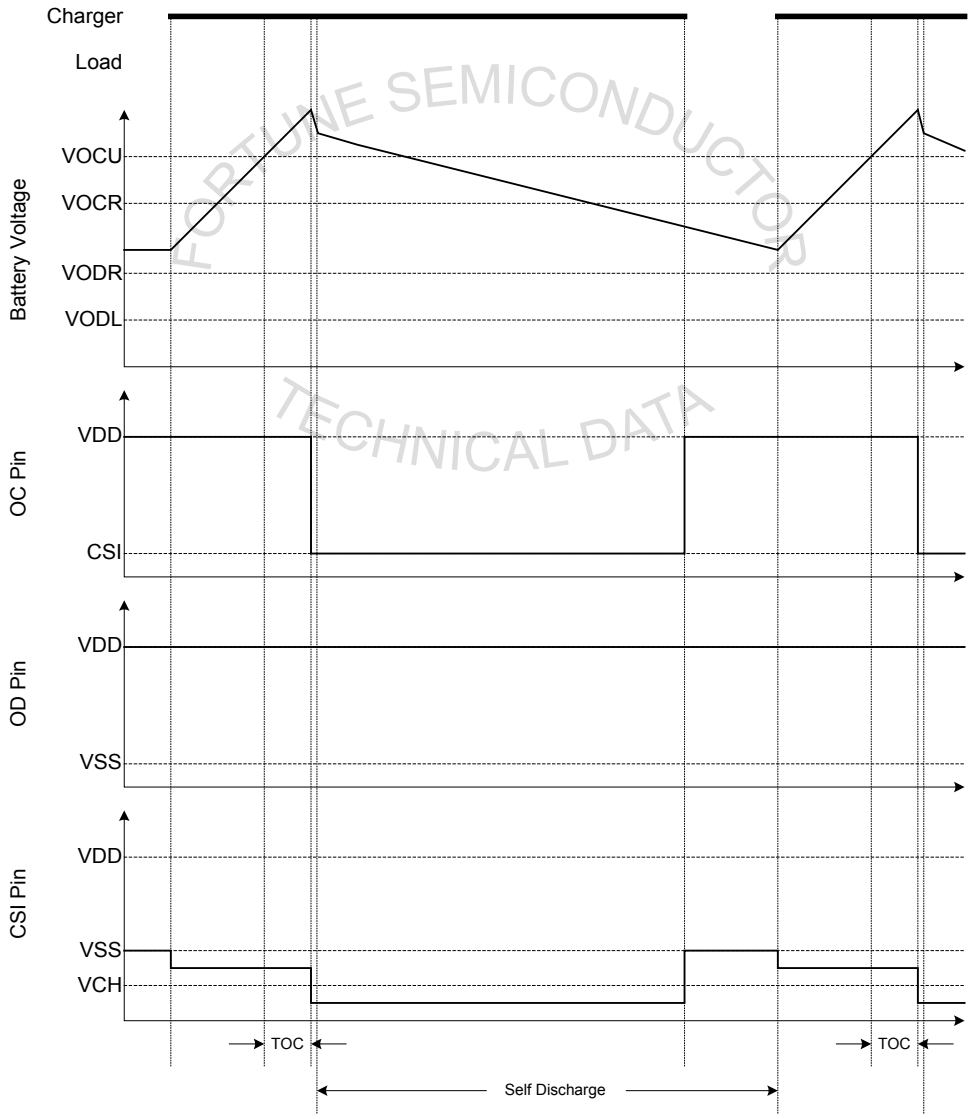
12.2 Overcharge Condition → Load Discharge → Normal Condition



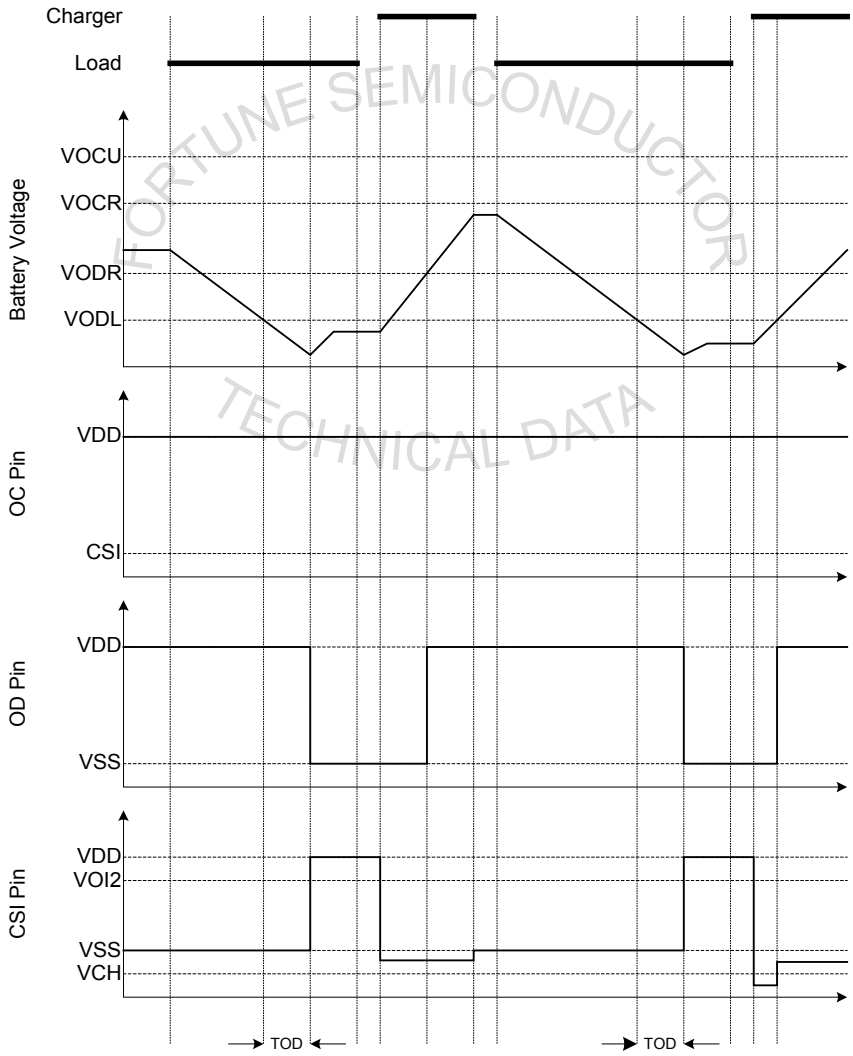
12.3 Overcharge Condition → Not remove the charger, and VCSI >VCH → Self Discharge



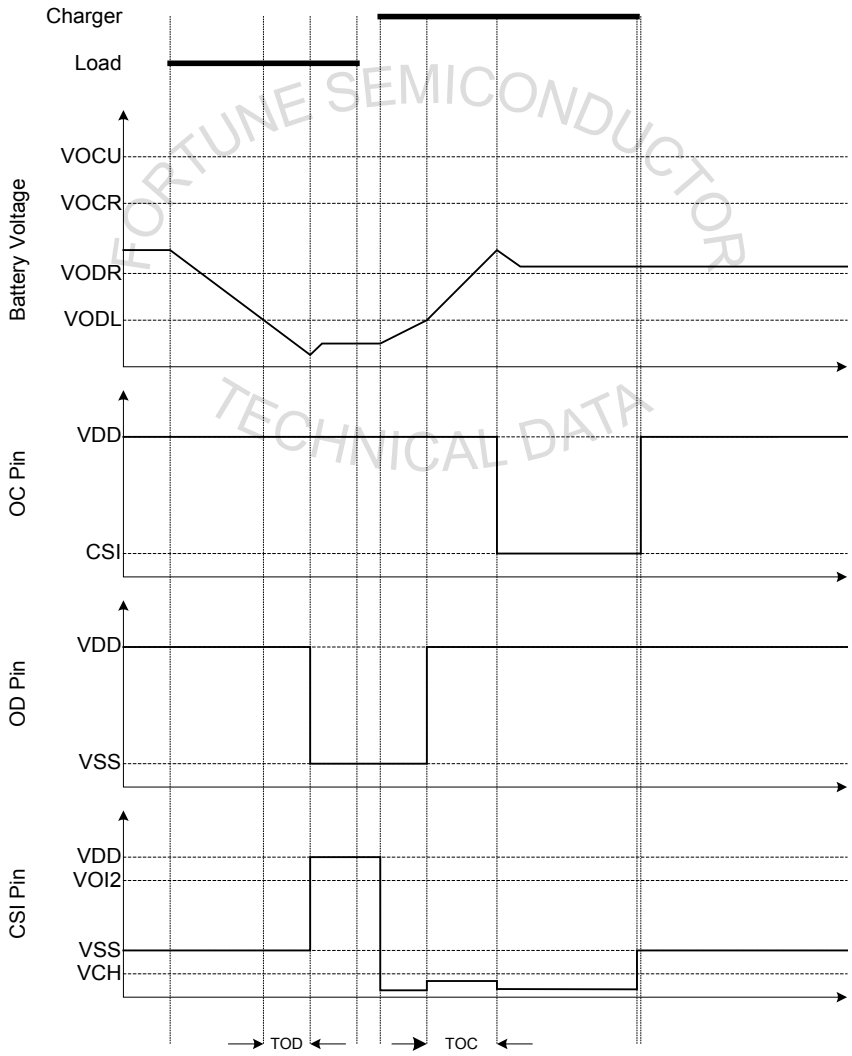
12.4 Overcharge Condition → Not remove the charger, and VCSI <VCH → Self Discharge



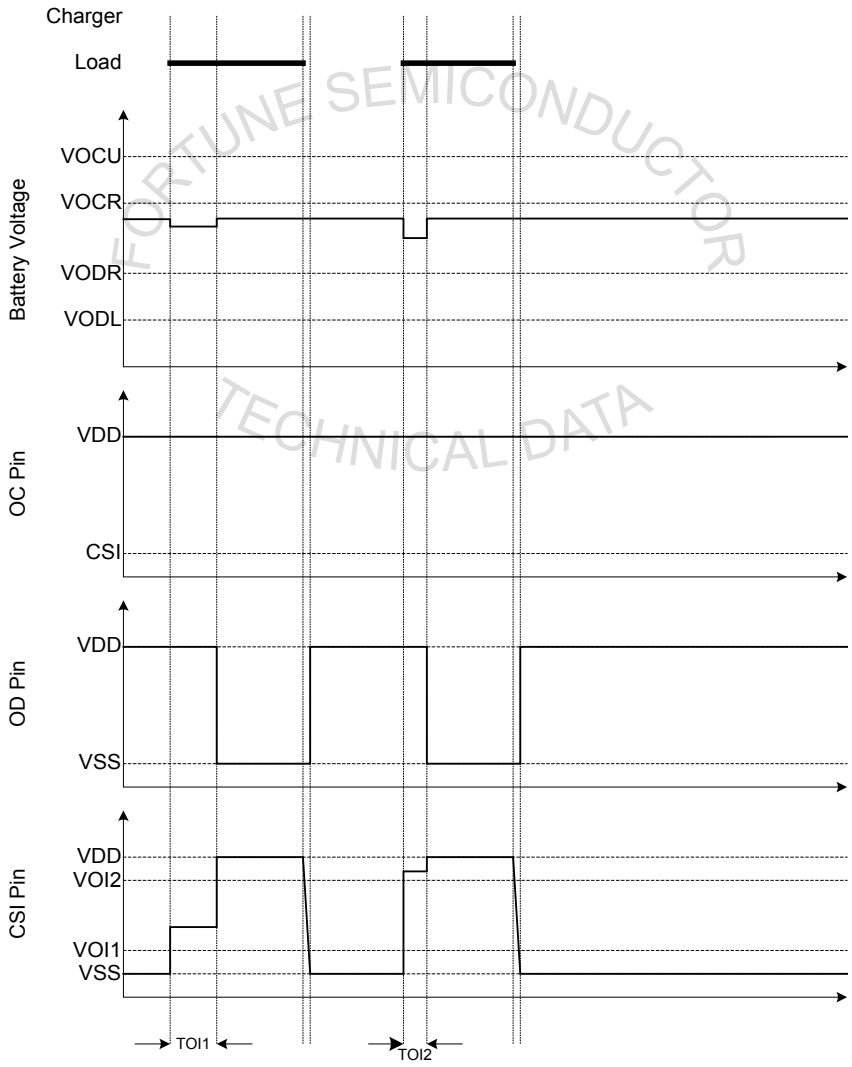
12.5 Overdischarge Condition → Charging by a charger → Normal Condition



12.6 Overdischarge Condition → Abnormal Charge Current Condition → Normal Condition

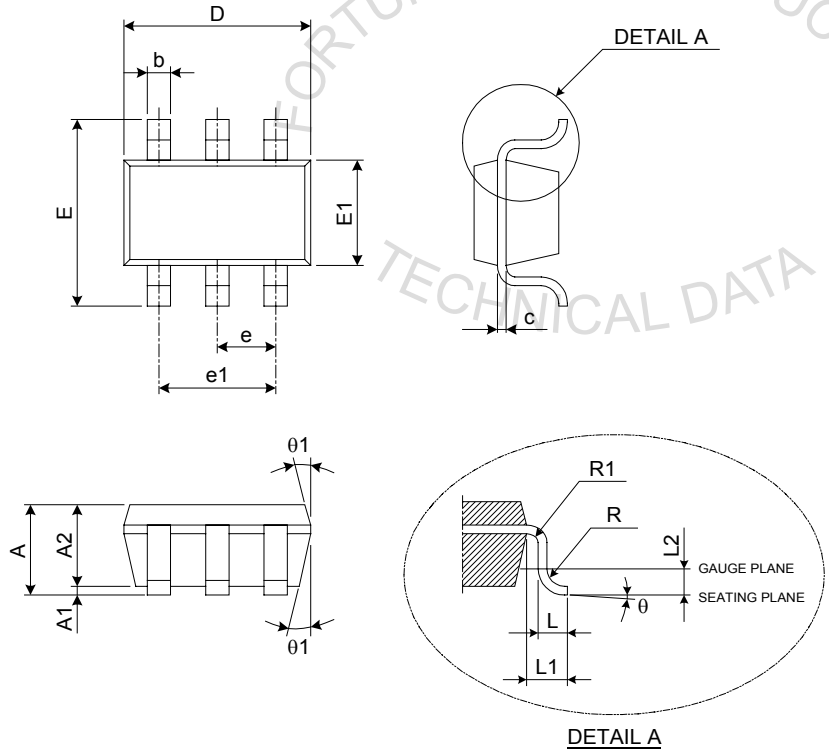


12.7 Over Current / Short Circuit Condition → Normal Condition



13. SOT-23-6

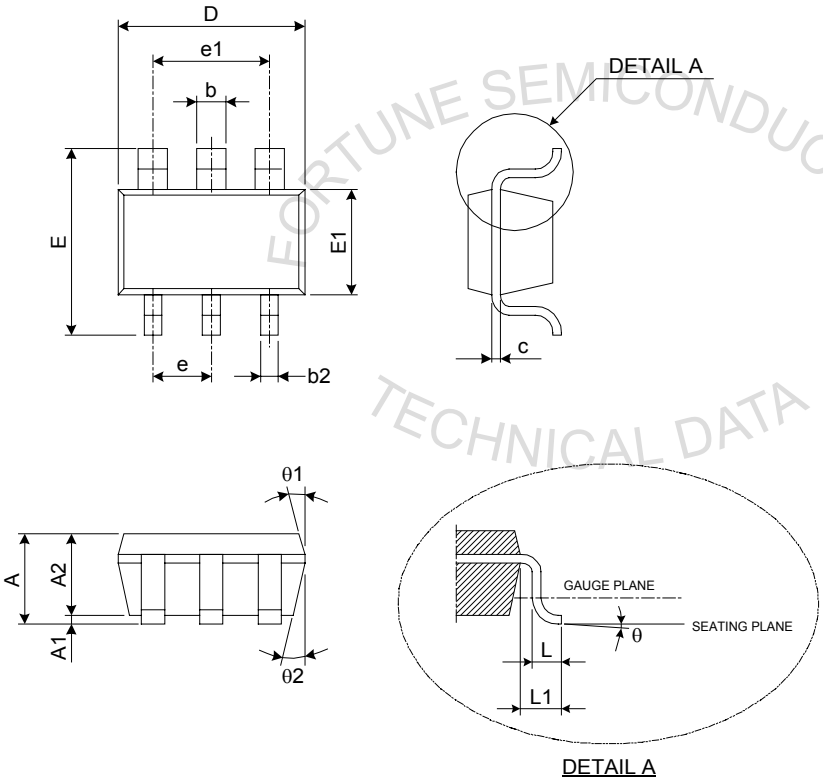
13.1 Dimensions (Package A)



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°