# FS301 Series Datasheet〔V1.1〕

## Lithium Battery Protection IC

## 1. Description

FS301 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 1 detection voltage [VOI1] (mV) |
|---|---|---|---|---|---|---|
| | SOT-23-6 | | | | | |
| FS301 | AN | 4.200±0.025 | 4.000±0.1 | 2.3±0.1 | 3.0±0.1 | 200±30 |
| | BN | 4.350±0.025 | 4.150±0.1 | 2.4±0.1 | 3.0±0.1 | 200±30 |
| | GN | 4.280±0.025 | 4.080±0.1 | 2.3±0.1 | 2.9±0.1 | 120±16 |
| | HN | 4.200±0.025 | 4.000±0.1 | 2.3±0.1 | 2.9±0.1 | 200±30 |
| | JN | 4.250±0.025 | 4.050±0.1 | 2.3±0.1 | 3.0±0.1 | 200±30 |
| | MN | 4.250±0.025 | 4.100±0.1 | 2.4±0.1 | 3.0±0.1 | 150±20 |
| | SN | 4.295±0.025 | 4.145±0.1 | 2.4±0.1 | 3.0±0.1 | 150±20 |
| | WN | 4.325±0.025 | 4.125±0.1 | 2.5±0.1 | 3.0±0.1 | 200±30 |

Overcharge and overdischarge voltages and overcurrent 1 detection voltage can be changed at the customer's request.

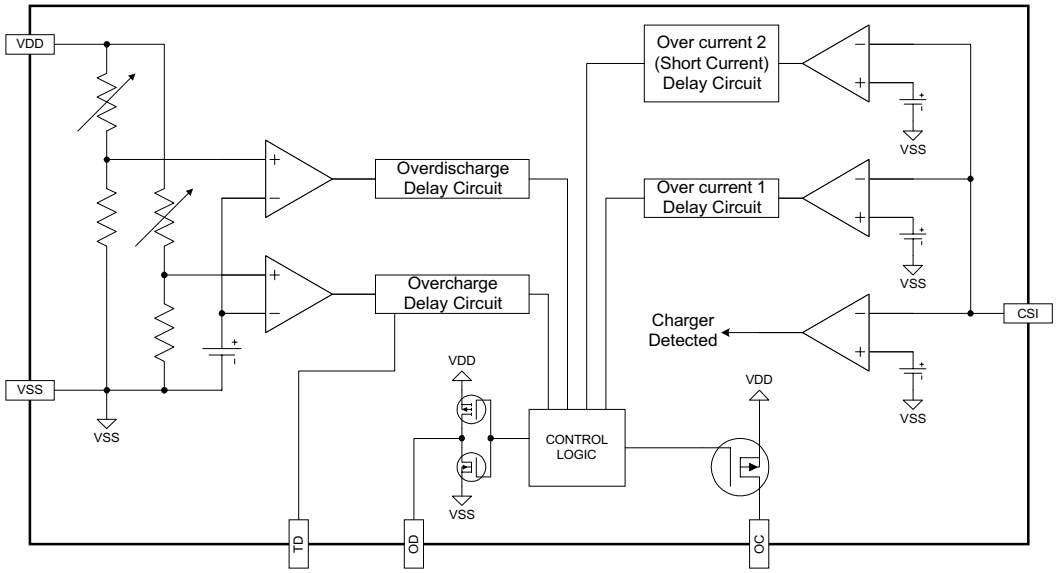
## 3. Features

| | | |
|---|---|---|
| 1) | Low supply current | Operation: 5.0uA typ. @VDD=3.5V<br>Power-down mode: 0.3uA typ. |
| 2) | Overcharge detection voltage〔VOCU〕 | 4.0V~4.4V, Accuracy of ±25mV |
| 3) | Overcharge release voltage〔VOCR〕 | VOCR, Accuracy of ±100mV |
| 4) | Overdischarge detection voltage〔VODL〕 | 2.3V~2.5V, Accuracy of ±100mV |
| 5) | Overdischarge release voltage〔VODR〕 | VODR, Accuracy of ±100mV |
| 6) | Over current 1 detection voltage〔VOI1〕 | VOI1 |
| 7) | Over current 2(Short Current) detection voltage〔VOI2〕 | 1.3V |
| 8) | Overcharge detection delay time | $C_{TD}$=0.01uF,100ms |
| 9) | Charger detection voltage | -0.6V |
| 10) | Load release function | >500KΩ |
| 11) | Wide supply voltage range | 1.8 ~ 8.0V |
| 12) | Small package | SOT-23-6 |

## Applications

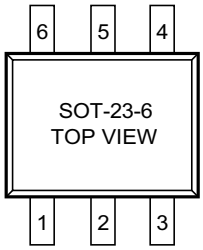
1) Protection IC for One-Cell Lithium-Ion Battery Pack

## 4. Block Diagram

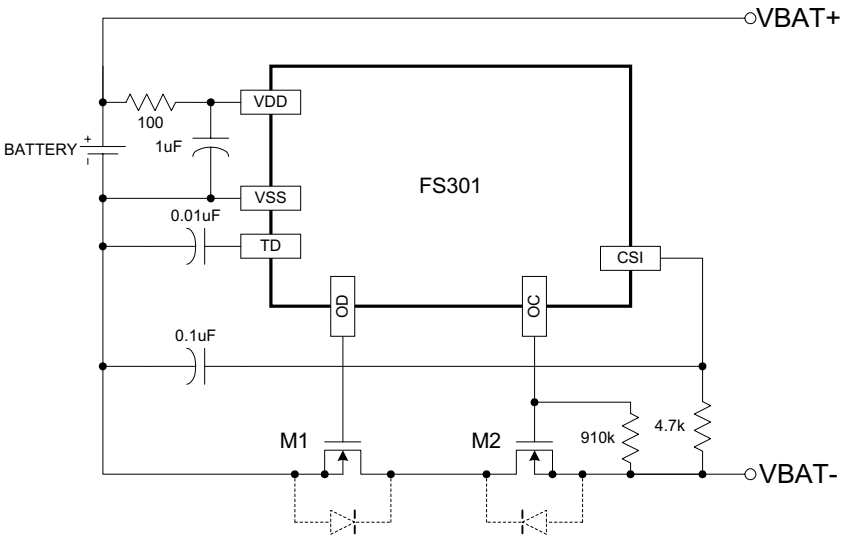



## 5. Pin Configuration

| Pin No. | Symbol | Description |
|---|---|---|
| 1 | CSI | Input pin for current sense, charger detect |
| 2 | VDD | Positive power input pin |
| 3 | TD | Pin for external capacitor setting output delay of VOCU |
| 4 | OC | PMOS open drain output for charge control |
| 5 | VSS | Negative power input pin |
| 6 | OD | FET gate connection pin for discharge control |



## 6. Typical Application Circuit




## 7. Absolute Maximum Ratings

| Item | Symbol | Rating | Unit |
|---|---|---|---|
| Supply voltage between VDD and VSS | VDD | VSS-0.3 to VSS+12 | V |
| OC output pin voltage | VOC | VDD-16 to VDD+0.3 | V |
| OD output pin voltage | VOD | VSS-0.3 to VDD+0.3 | V |
| CSI input pin voltage | VCSI | VDD-16 to VDD+0.3 | V |
| Operating Temperature Range | TOP | -10 to +70 | ℃ |
| Storage Temperature Range | TST | -40 to +125 | ℃ |

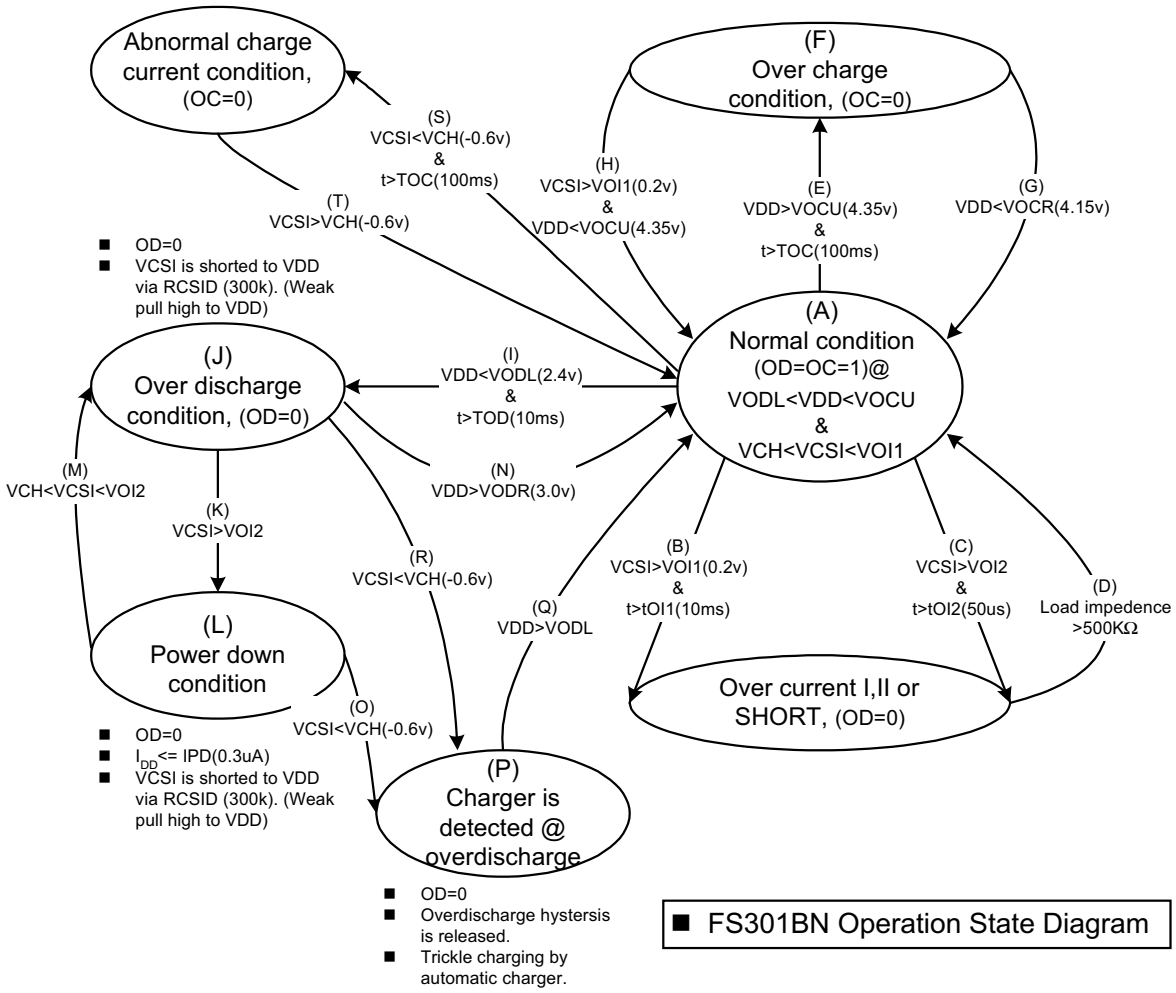
## 8. Electrical Characteristic

(Unless otherwise specified Ta=25℃, VDD=3.5V, model name FS301BN)

| PARAMETER | CONDITIONS | SYMBOL | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| **CURRENT CONSUMPTION** | | | | | | |
| Supply Current | VDD=3.5V | IDD | | 5.0 | 10.0 | uA |

| | | | | | | |
|---|---|---|---|---|---|---|
| Power-Down Current | VDD=2.3V | IPD | | 0.3 | 0.5 | uA |
| **OPERATING VOLTAGE** | | | | | | |
| Operating voltage between VDD and VSS | | VDD | 1.8 | | 8.0 | V |
| **DETECTION VOLTAGE** | | | | | | |
| Overcharge detection voltage | | VOCU | 4.325 | 4.350 | 4.375 | V |
| Overcharge release voltage | | VOCR | 4.05 | 4.15 | 4.25 | V |
| Overdischarge detection voltage | | VODL | 2.3 | 2.4 | 2.5 | V |
| Overdischarge release voltage | | VODR | 2.9 | 3.0 | 3.1 | V |
| Over current 1 detection voltage | VDD=3.5V | VOI1 | 0.17 | 0.2 | 0.23 | V |
| Over current 2 (Short Current) detection voltage | VDD=3.5V | VOI2 | 1.2 | 1.3 | 1.4 | V |
| Charger detection voltage | VDD=3.5V | VCH | -0.8 | -0.6 | -0.4 | V |
| **DELAY TIME** | | | | | | |
| Overcharge detection delay time | $C_{TD}$=0.01uF | TOC | 50 | 100 | 150 | ms |
| Overdischarge detection delay time | | TOD | 5 | 10 | 15 | ms |
| Over current 1 detection delay time | VDD=3.5V | TOI1 | 5 | 10 | 15 | ms |
| Over current 2 (Short Current) detection delay time | VDD=3.5V | TOI2 | | 50 | 200 | us |
| **OTHER** | | | | | | |
| OC pin source current | VDD=3.5V, OC pin short to VSS | IOC | 300 | 400 | 500 | uA |
| OD pin output “H” voltage | | VDH | VDD-0.1 | VDD-0.02 | | V |
| OD pin output “L” voltage | | VDL | | 0.01 | 0.1 | V |
| | | | | | | |

## 9. State Diagram of Operation




## 10. Description of Operation

### 10.1 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.

### 10.2 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.

### 10.3 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.

### 10.4 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).

### 10.5 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.

### 10.6 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.

### 10.7 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.

### 10.8 Over Current/Short Current Detection

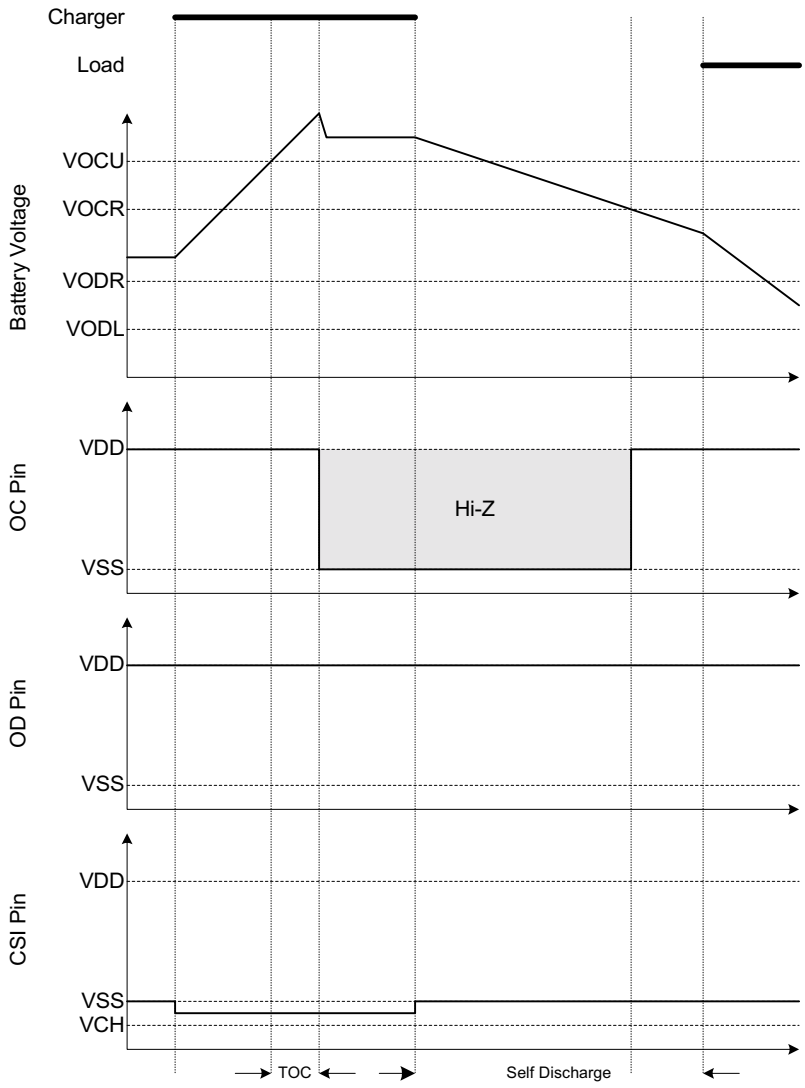
When the discharging current is too large during discharging under normal condition and the voltage detected from CSI is larger than VOIX (VIO1 or VIO2) for over a certain delay time TOIX (TIO1 or TIO2), it means the over current/short current condition occurred. M1 is turned off. CSI is pulled to VSS by way of an internal resistance, RCSIS.

### 10.9 Release of Over Current/Short Current Condition

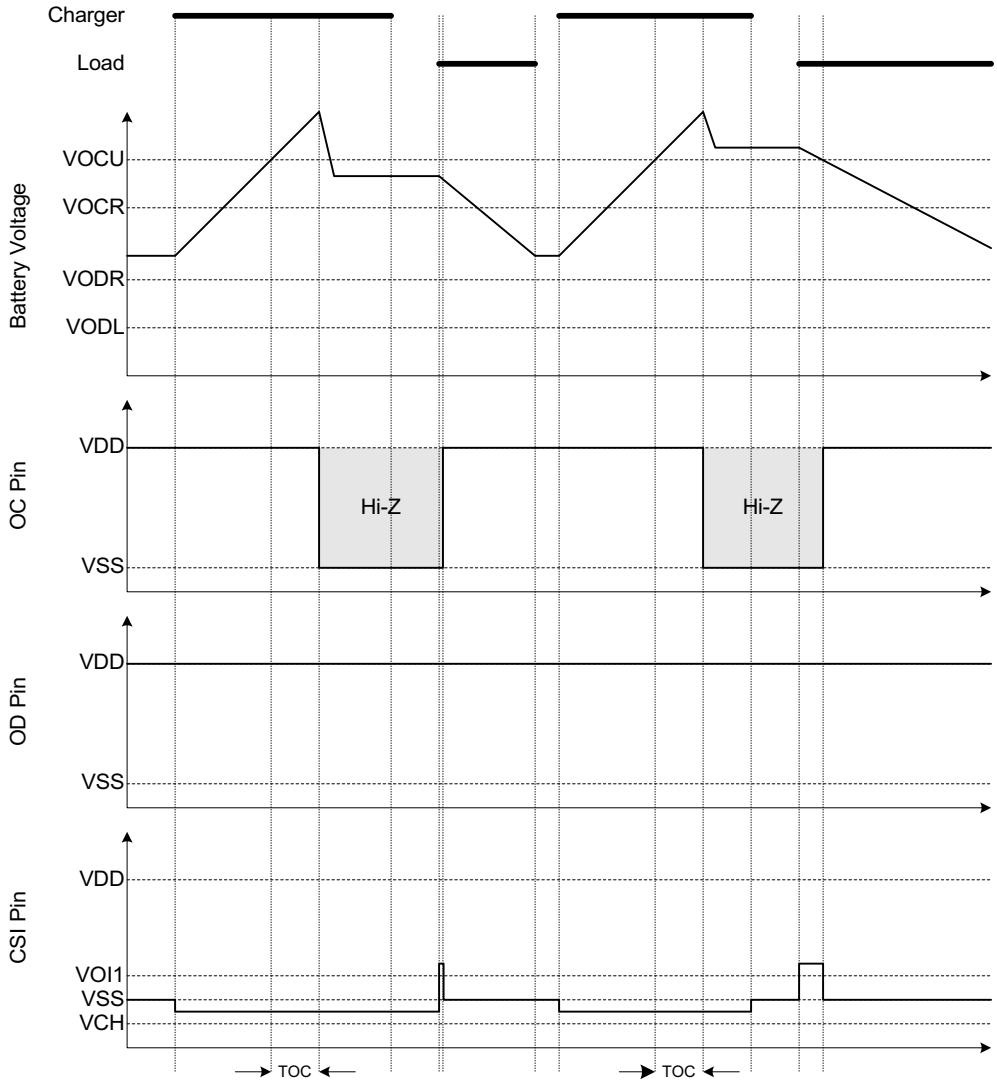
While the protection IC remains in Over Current/Short Current condition and load is removed or the impedance between VBAT+ and VBAT- is larger than 500KΩ and VCSI<VOI1, M1 is to be turned on and back to normal condition.

## 11. Timing Diagram

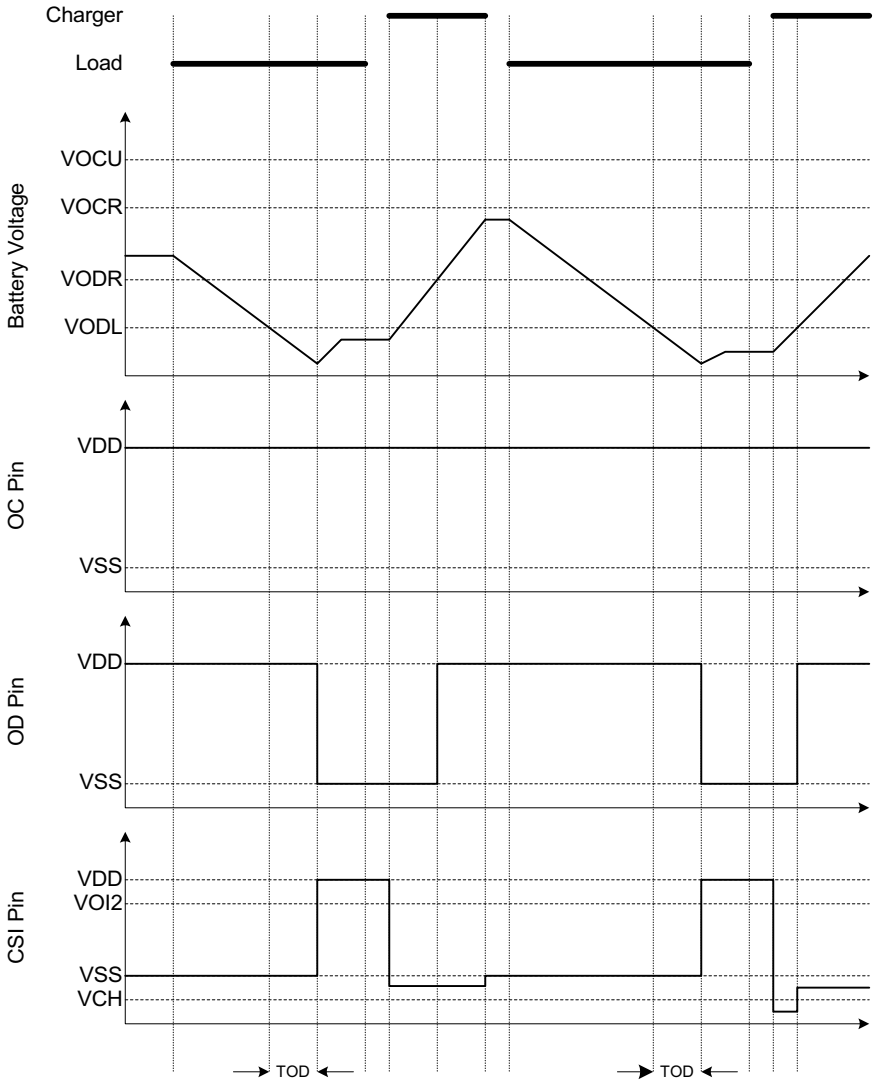
### 11.1 Overcharge Condition →Self Discharging → Normal Condition



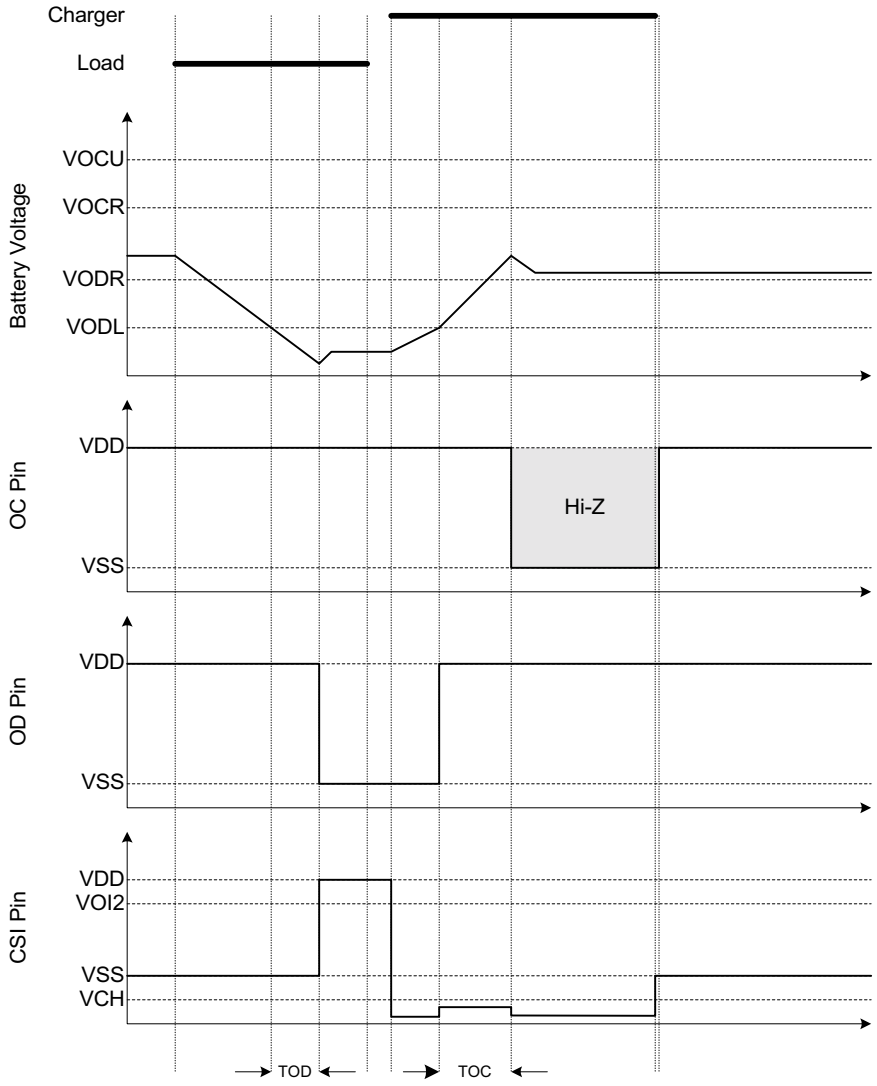
### 11.2 Overcharge Condition →Load Discharging → Normal Condition



### 11.3 Overdischarge Condition → Charging by a Charger →Normal Condition



### 11.4 Overdischarge Condition → Abnormal Charging →Normal Condition



### 11.5 Over Current Condition → Normal Condition