

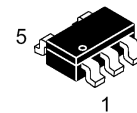
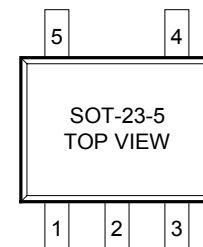
Product Name List

| 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-23-5 | | | | | |
| FS325 | A | 4.280±0.025 | 4.130±0.05 | 2.80±0.08 | 3.10±0.08 | 100±30 |
| | B | 4.300±0.025 | 4.080±0.05 | 2.50±0.08 | 2.90±0.08 | 150±30 |
| | C | 4.300±0.040 | 4.080±0.05 | 2.50±0.08 | 2.90±0.08 | 150±30 |

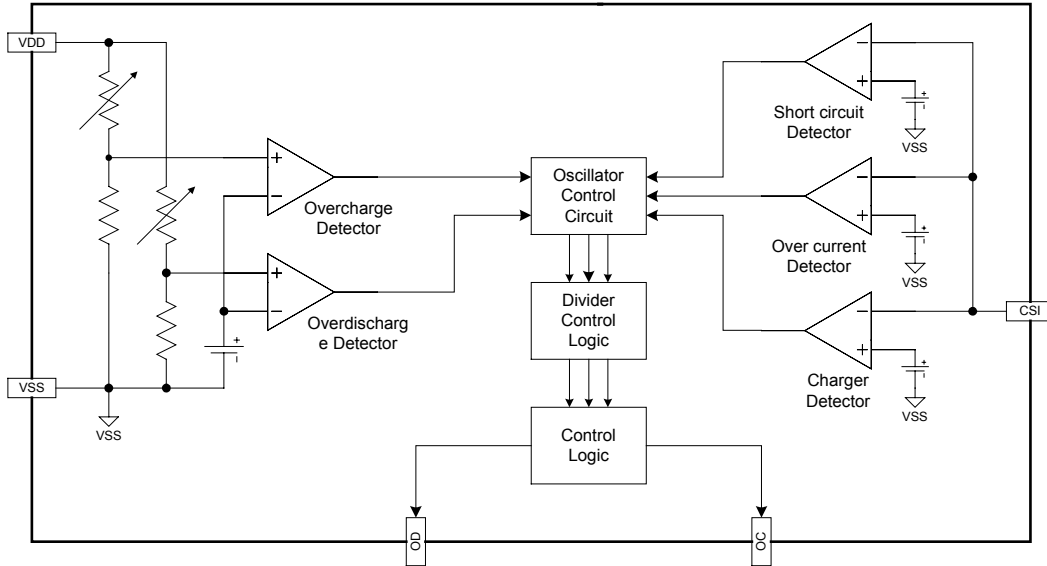
Overcharge and overdischarge and overcurrent detection voltages can be changed at the customer's request.

Pin Configuration

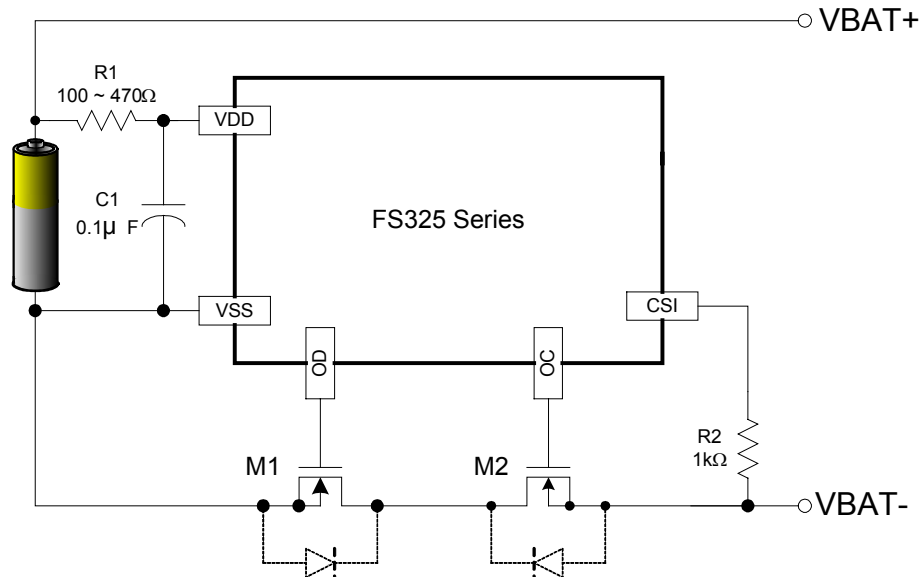
| Pin No. | Symbol | Description |
|---------|--------|---|
| 1 | CSI | Input pin for current sense, charger detect |
| 2 | VDD | Positive power input pin |
| 3 | VSS | Negative power input pin |
| 4 | OD | FET gate connection pin for discharge control |
| 5 | OC | FET gate connection pin for charge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



Functional Block Diagram



Typical Application Circuit



Absolute Maximum Ratings

(VSS=0V, Ta=25°C 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 | °C |
| Storage Temperature Range | TST | -40 to +125 | °C |

Note: FS325 contains a circuit that will protect it from static discharge; but please take special care that no excessive static electricity or voltage which exceeds the limit of the protection circuit will be applied to it.

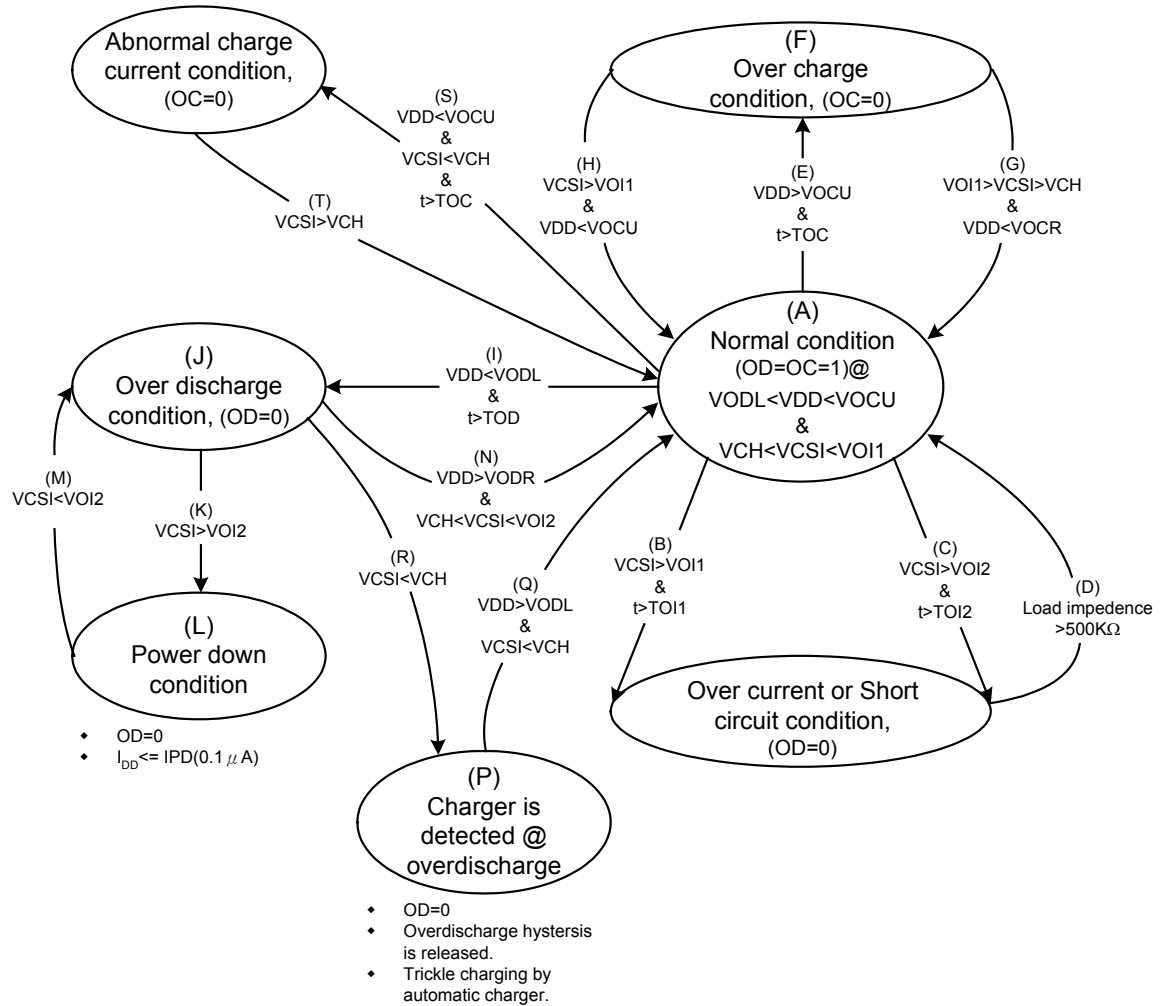
* Pulse (μ sec) noise exceeding the above input voltage (VSS+12V) may cause damage to the IC.

Electrical Characteristics

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

| PARAMETER | CONDITIONS | SYMBOL | Min | Typ | Max | UNIT |
|--|-----------------------|--------|----------------|-------|----------------|------|
| CURRENT CONSUMPTION | | | | | | |
| Supply Current | VDD=3.9V | IDD | | 3.0 | 6.0 | μ A |
| Power-Down Current | VDD=2.0V | IPD | | | 0.1 | μ A |
| 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 | -1.8 | -1.35 | -0.9 | 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 | μ s |
| OTHER | | | | | | |
| OC pin output "H" voltage | VDD=3.9V, Ioh=-50 μ A | 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=-50 μ A | Voh2 | 3.4 | 3.7 | | V |
| OD pin output "L" voltage | VDD=2.0V, Iol=50 μ A | Vol2 | | 0.1 | 0.5 | V |

State Diagram of Operation



Description of Operation

1. Normal Condition

The FS325 monitors the voltage of the battery connected between VDD and VSS. The charge and discharge scheme will be sensed by the voltage difference between CSI and VSS. When $VODL < VDD < VDCU$ and $VCH < VCSI < VOI1$, FS325 will turn on the charging (M2) and discharging (M1) control MOSFETs. The charging and discharging processes can be operated normally. This is called the normal condition.

Note: When a battery is connected to FS325 for the first time, it may not enter the normal condition (dischargeable may not be enabled). In this case, short the CSI and VSS pins or connect a charger to restore to the normal condition.

2. Overcharge Condition

When the battery voltage becomes higher than the overcharge detection voltage (VDCU) during normal charging condition through a delay time longer than TOC (the overcharge detection delay time), FS325 will turn M2 off to stop charging. This condition is called the overcharge condition.

3. Release of Overcharge Condition

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

- 1) When the battery is self discharging, and if $VDD < VDCR$ and $VOI1 > VCSI > VCH$ occurs, M2 will be turned on and back to normal condition.
- 2) Remove the charger and connect FS325 to a load, the discharging current will flow through the parasitic diode of M2. At this moment, VCSI increases a voltage (VF) of the parasitic diode from the VSS level momentarily. While $VCSI > VOI1$ and $VDD < VDCU$ occurs, M2 will be turned on and back to normal condition.

Note 1: After entering into the overcharge condition, if the charger remains connected and $VOI1 > VCSI > VCH$, then M2 will be turned on when the voltage of the battery is lower than VDCR (because the self-discharge of the battery). The system can enter the charging status again as 1).

Note 2: After entering the overcharge condition, if the charger remains connected and $VCSI < VCH$, then M2 will be kept off even though the voltage of the battery is lower than VDCR (because the self-discharge of the battery), and the system will not be allowed to back to the charging status.

4. Overdischarge Condition

When the battery voltage falls below the overdischarge detection voltage (VODL) during discharging condition through a delay time longer than TOD (the overdischarge detection delay time), FS325 will turn M1 off to stop discharging. This is called the overdischarge condition. In the meanwhile, CSI is pulled up to VDD by way of internal resistance. If $VCSI > VOI2$, FS325 will enter into power-down mode. While in this mode, the current consumption is lower than $0.1 \mu A$.

5. Release of Power-down mode

After entering power-down mode, when the system is connected to a charger, the charging current will flow through the parasitic diode of M1. If $V_{CSI} < V_{OI2}$ occurs, then FS325 will release power-down mode. While keeping charging status, there are two ways back to normal condition:

- 1) If $V_{CSI} < V_{CH}$ (Charger detection), then when $V_{DD} > V_{ODL}$, M1 will be turned on and the system will back to normal condition.
- 2) If $V_{CH} < V_{CSI} < V_{OI2}$, the condition $V_{DD} > V_{ODR}$ must be satisfied for M1 to be turned on, and then the system will back to the normal condition.

6. Charger Detection

While connecting to a charger after entering into power-down mode, then if $V_{CSI} < V_{CH}$, M1 will be turned on when $V_{DD} > V_{ODL}$. The system will back to normal condition as described in 1) of previous section since the charger has been detected. This action is called charger detection.

7. Abnormal Charge Current Condition

When a charger is connected to the battery system in normal condition, then if $V_{DD} < V_{OCU}$ and $V_{CSI} < V_{CH}$ occurs through a delay time longer than TOC (delay time of overcharge detection), M2 will be turned off to stop this charging status. It 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 (V_{CH}), or the charger is removed.

8. Over Current / Short Circuit Condition

When the current is too large during discharging under normal condition as a result of the voltage detected by CSI is greater than V_{OI1} (or V_{OI2}) for a delay time longer than $TOI1$ (or $TOI2$), it satisfies the over current (or short circuit) condition. Then M1 will be turned off and CSI will be pulled down to VSS through an internal resistance. It is called the over current (or short circuit) condition.

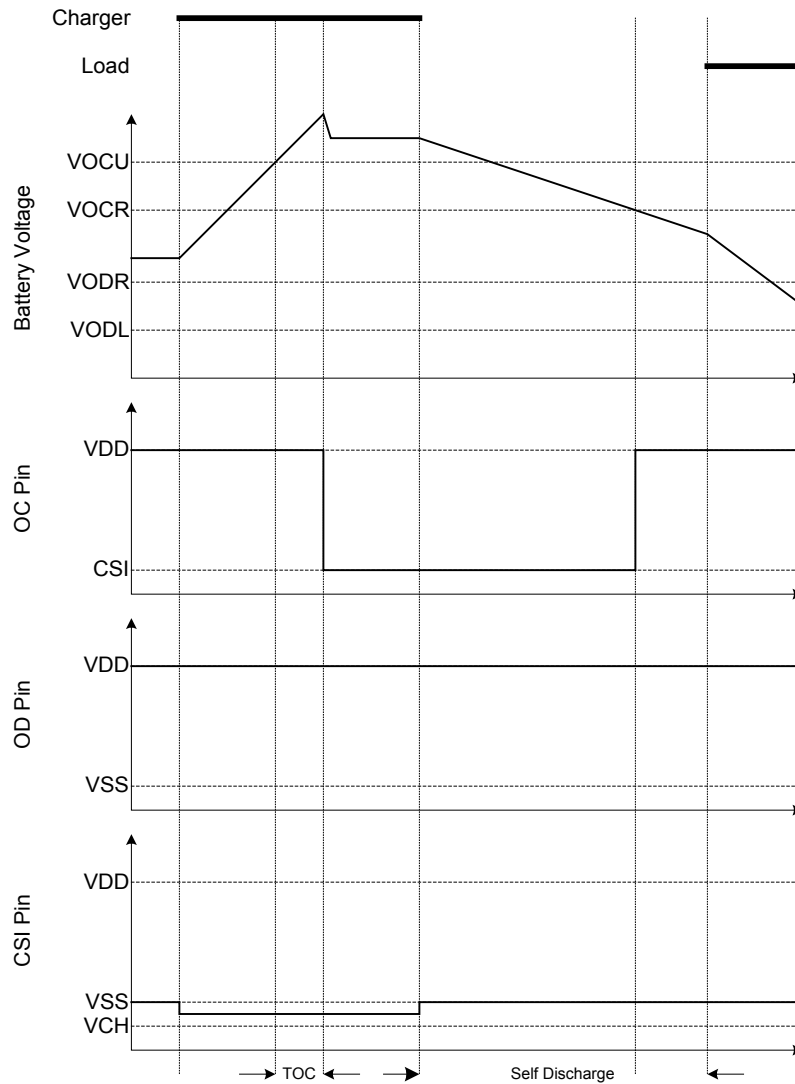
- If the over current / short circuit is detected and it keeps longer than the overdischarge detection delay time with the same circumstance, the condition will be changed to power-down mode when the battery voltage falls below the overdischarge detection voltage.
- If the battery voltage falls below the overdischarge detection voltage (V_{ODL}) due to the over current / short circuit, the discharging control FET (M1) will be turned off when this condition occurred. After overdischarge detection delay time (TOD) expired, if the battery voltage is still equal to or lower than the overdischarge detection voltage, the condition will then be changed to power-down mode.

9. Release of Over Current / Short Circuit Condition

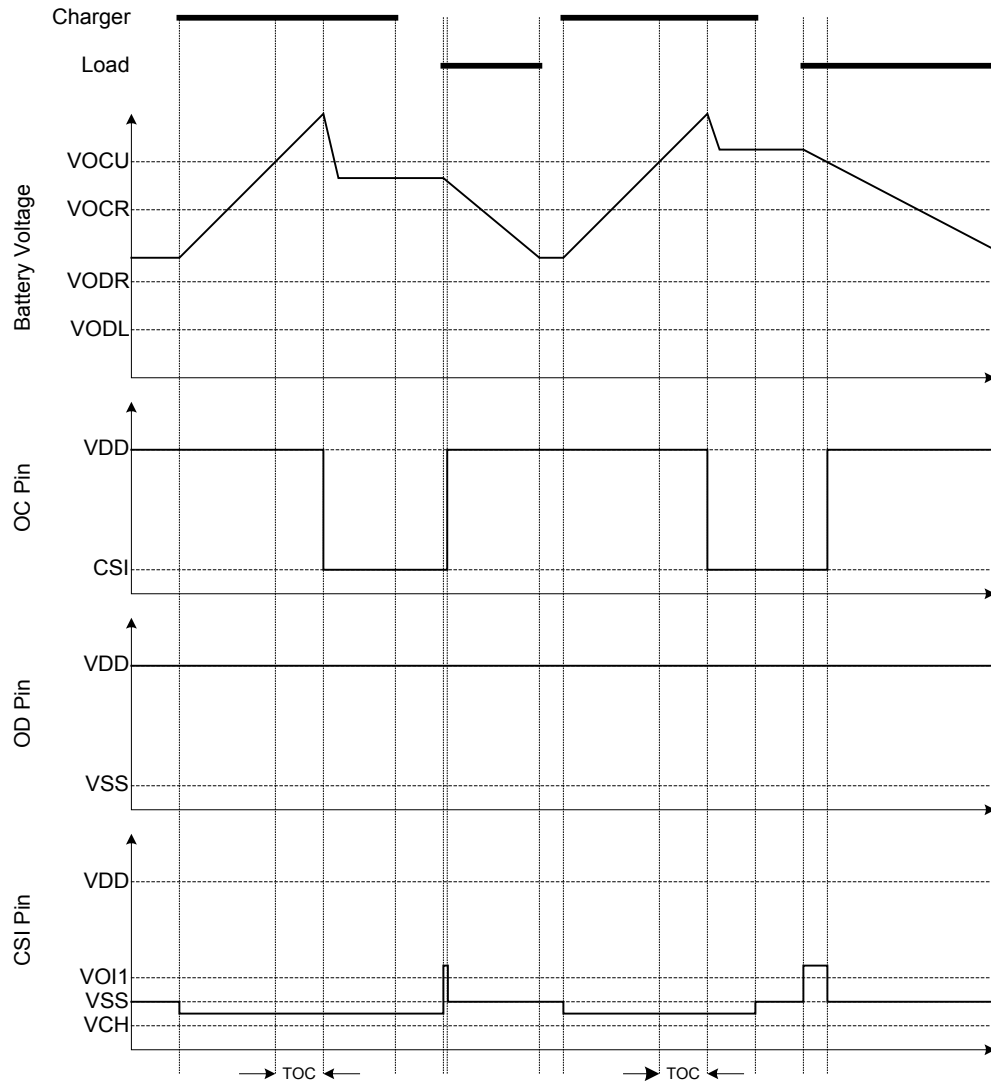
While the protection IC remains in Over current/Short circuit condition, then if the load is removed or the impedance between VBAT+ and VBAT- is larger than $500k\Omega$ as well as $V_{CSI} < V_{OI1}$, M1 will be turned on and then back to normal condition.

Timing Diagram

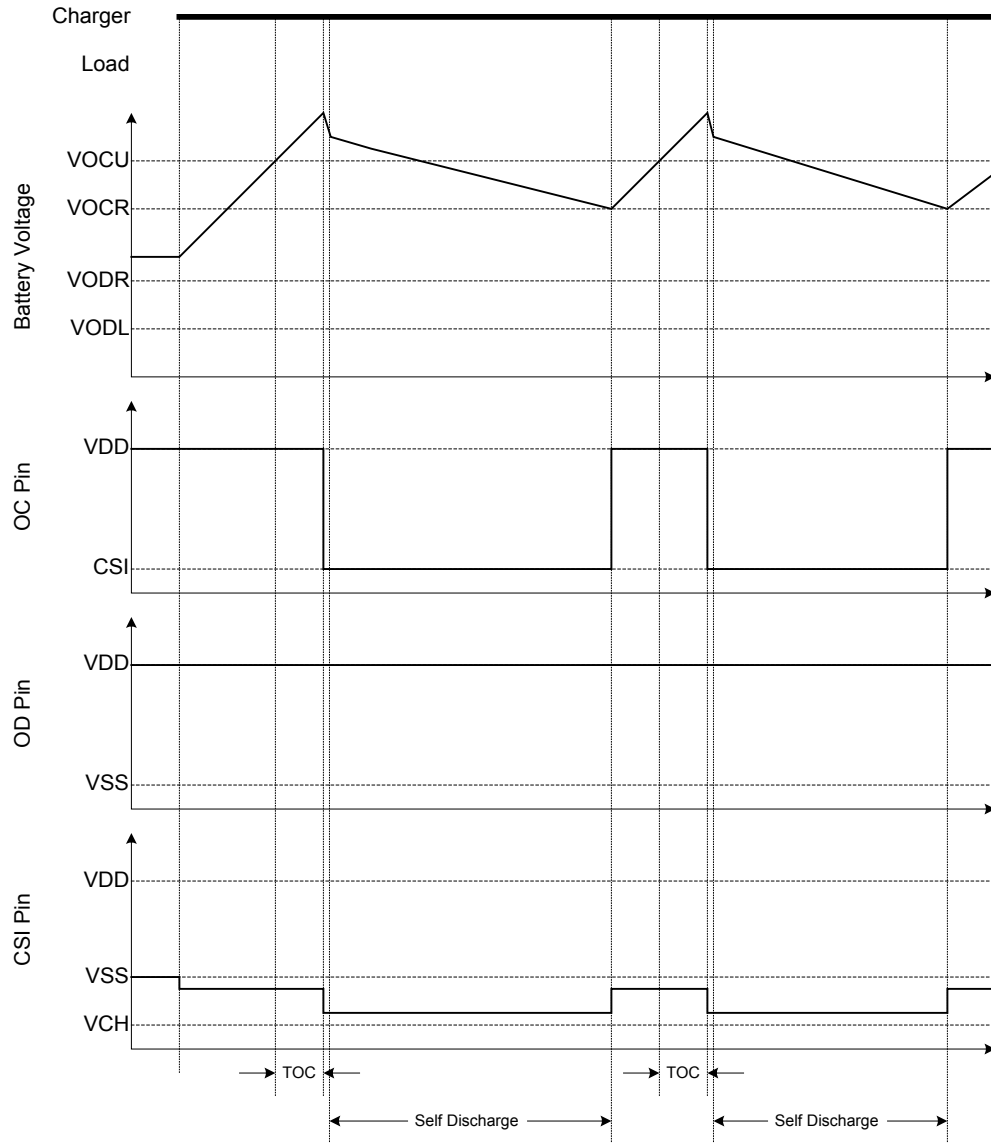
1. Overcharge Condition → Self Discharge → Normal Condition



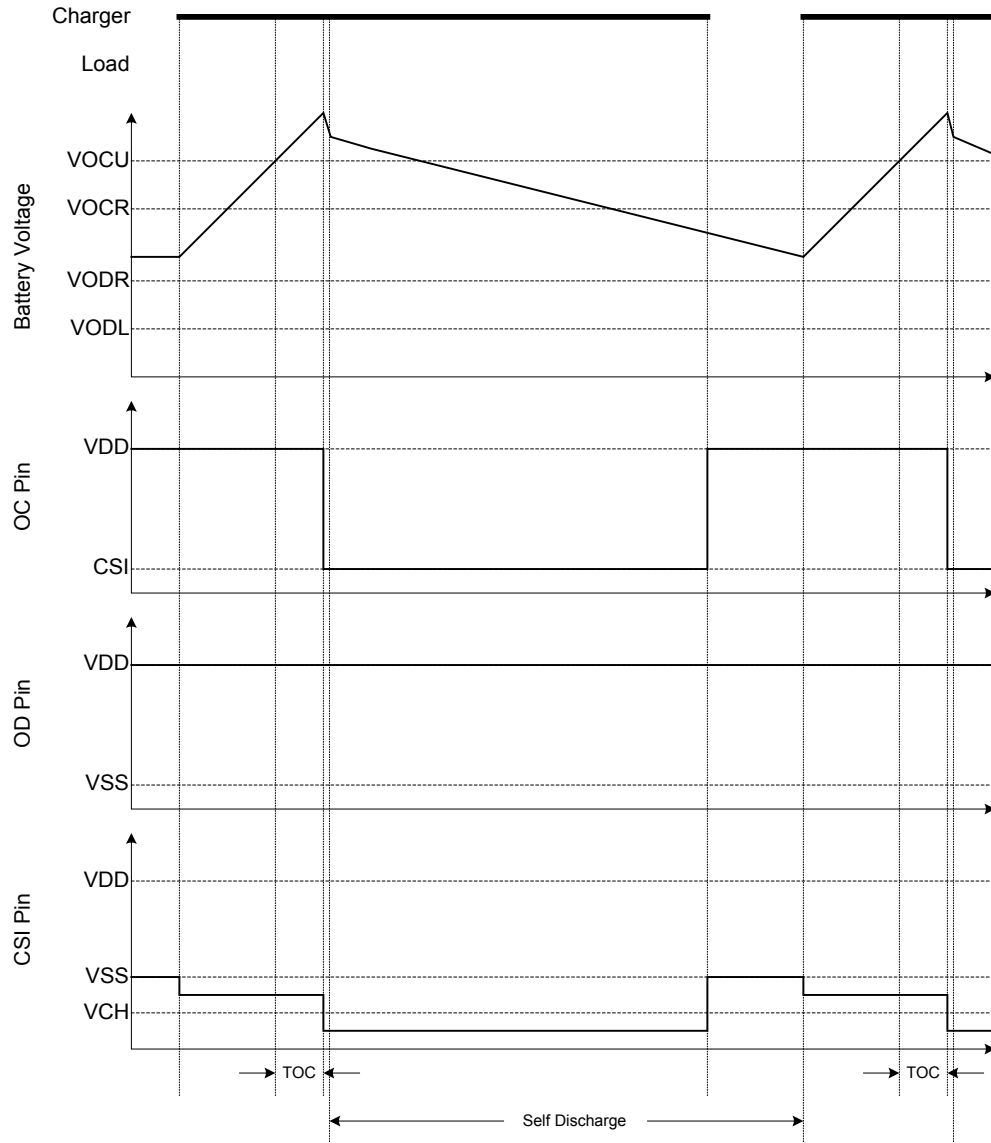
2. Overcharge Condition → Load Discharge → Normal Condition



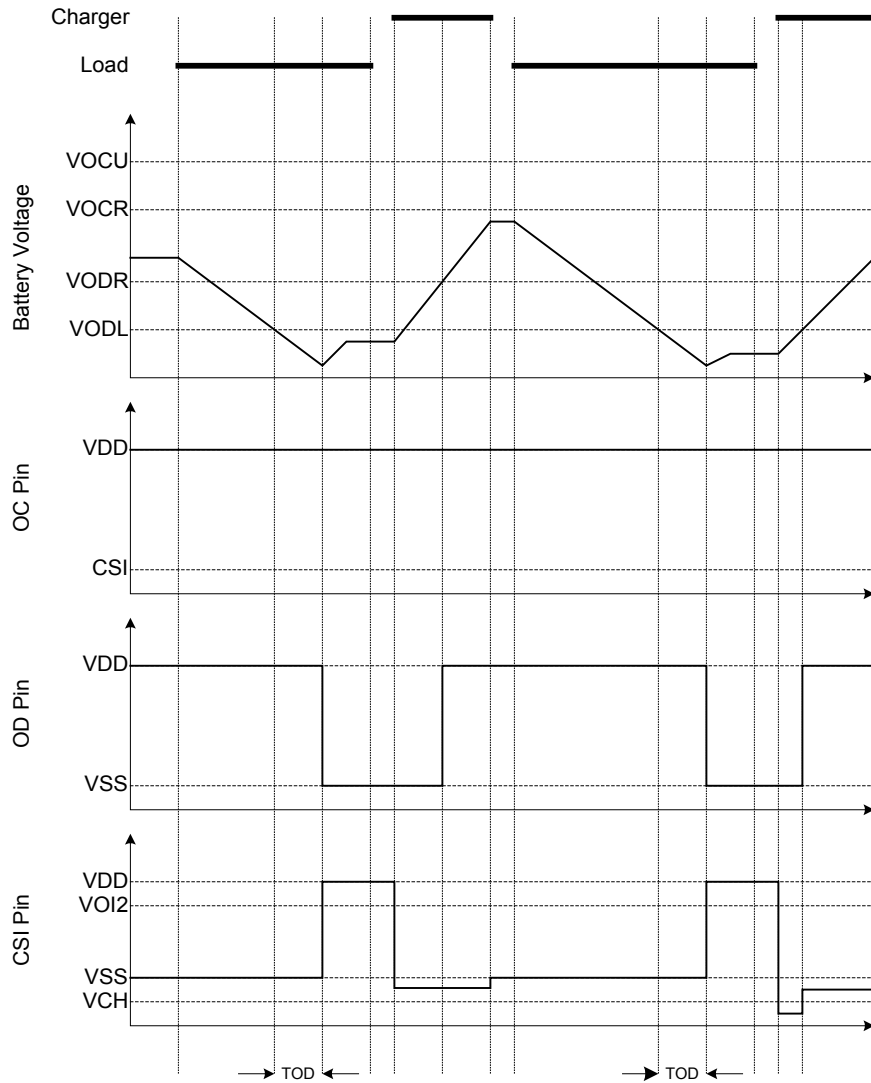
3. Overcharge Condition → Charger remains connected and $V_{CSI} > V_{CH}$ → Self Discharge



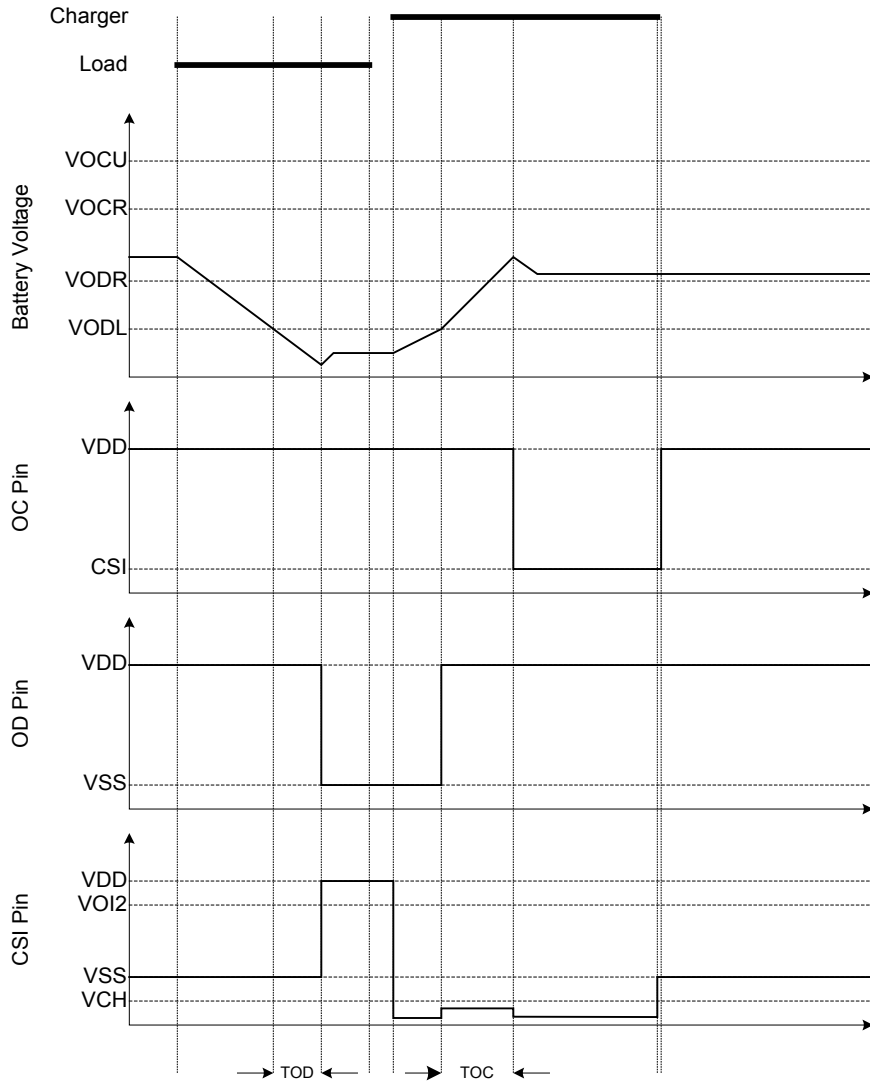
4. Overcharge Condition → Charger remains connected and $V_{CSI} < V_{CH}$ → Self Discharge



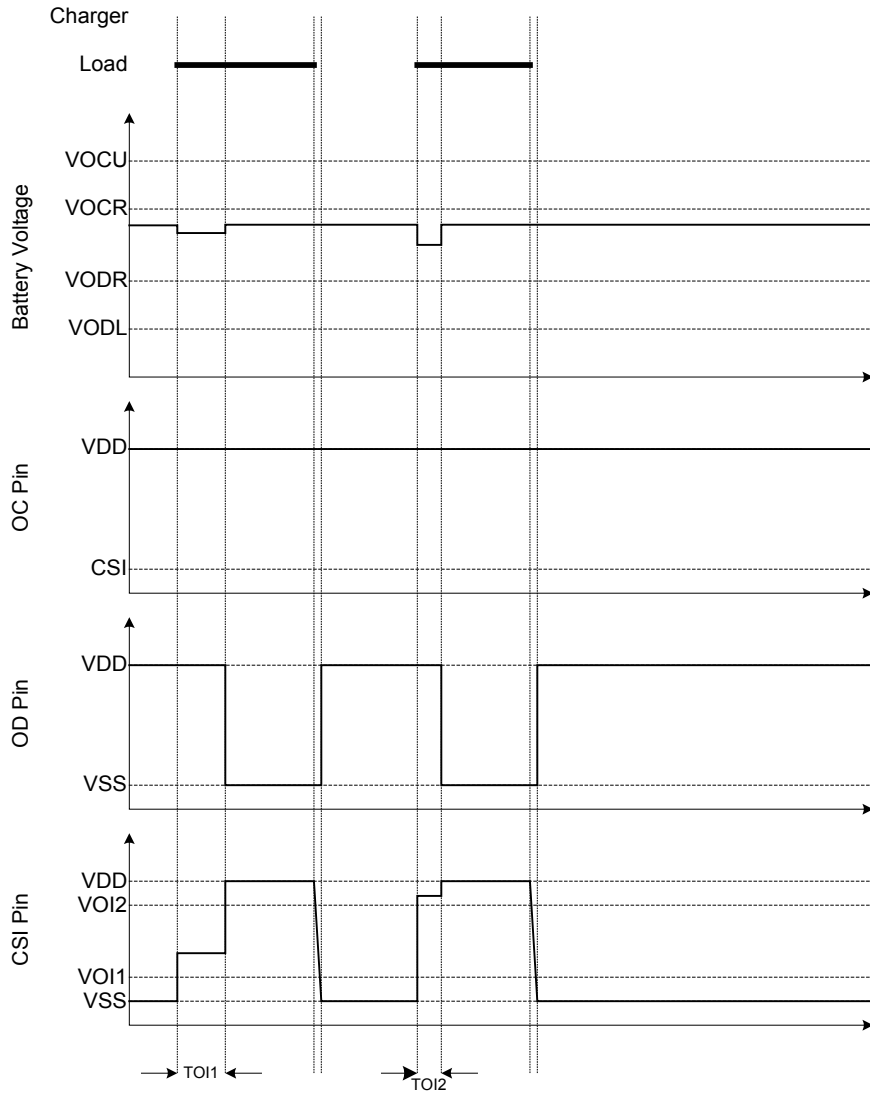
5. Overdischarge Condition → Charging by a Charger → Normal Condition



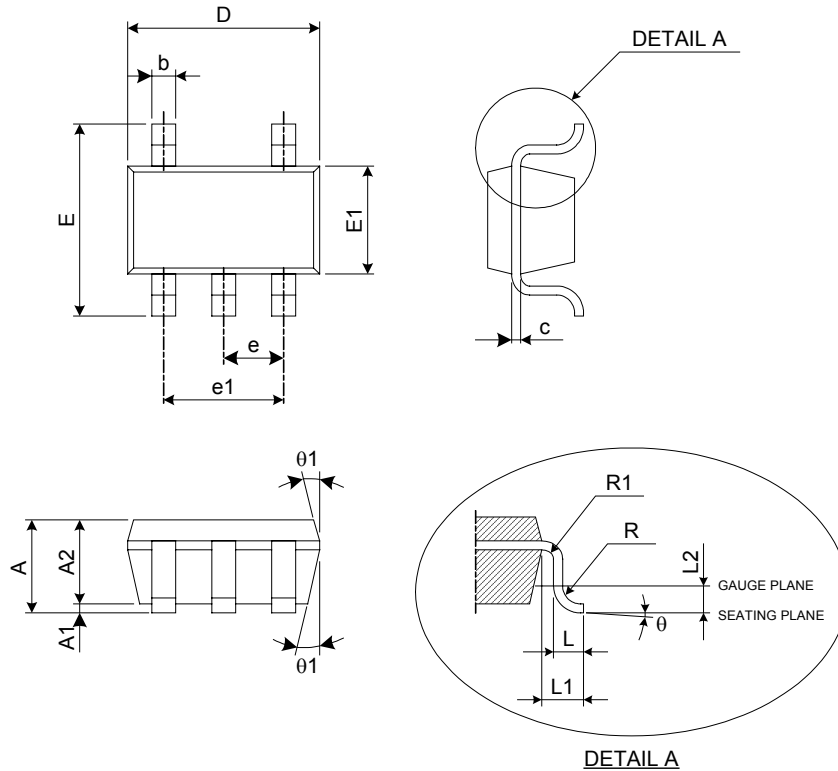
6. Overdischarge Condition → Abnormal Charge Current Condition → Normal Condition



7. Over Current / Short Circuit Condition → Normal Condition



Package Outline



Unit : mm

| SYMBOL | MIN. | TYP. | MAX. |
|------------|-----------|------|------|
| A | 1.05 | - | 1.35 |
| A1 | 0.05 | - | 0.15 |
| A2 | 1.00 | 1.10 | 1.20 |
| b | 0.25 | - | 0.50 |
| c | 0.08 | - | 0.20 |
| D | 2.90 BSC. | | |
| E | 2.80 BSC. | | |
| E1 | 1.60 BSC. | | |
| e | 0.95 BSC. | | |
| e1 | 1.90 BSC. | | |
| L | 0.35 | 0.45 | 0.55 |
| L1 | 0.60 REF. | | |
| L2 | 0.25 BSC. | | |
| R | 0.10 | - | - |
| R1 | 0.10 | - | 0.25 |
| θ | 0° | 5° | 10° |
| $\theta 1$ | 3° | 5° | 7° |