

Single-Cell Lithium-Ion Battery Protection IC

FEATURES

- Reduction in board size with miniature SOT-23-5 package and few external components.
- Ultra-low quiescent current of $7\mu\text{A}$ ($V_{\text{CC}}=3.5\text{V}$).
- Ultra-low power-down current of $0.6\mu\text{A}$ ($V_{\text{CC}}=2.2\text{V}$).
- Precision over-charge protection voltage
 - $4.35\text{V} \pm 50\text{mV}$ for the SS6821A
 - $4.30\text{V} \pm 50\text{mV}$ for the SS6821B
 - $4.25\text{V} \pm 50\text{mV}$ for the SS6821C
 - $4.20\text{V} \pm 50\text{mV}$ for the SS6821D
- Built-in delay-time circuits for over-charge, over-discharge, and over-current protection.
- Load detection function during overcharge mode.
- Two detection levels for over-current protection.

APPLICATIONS

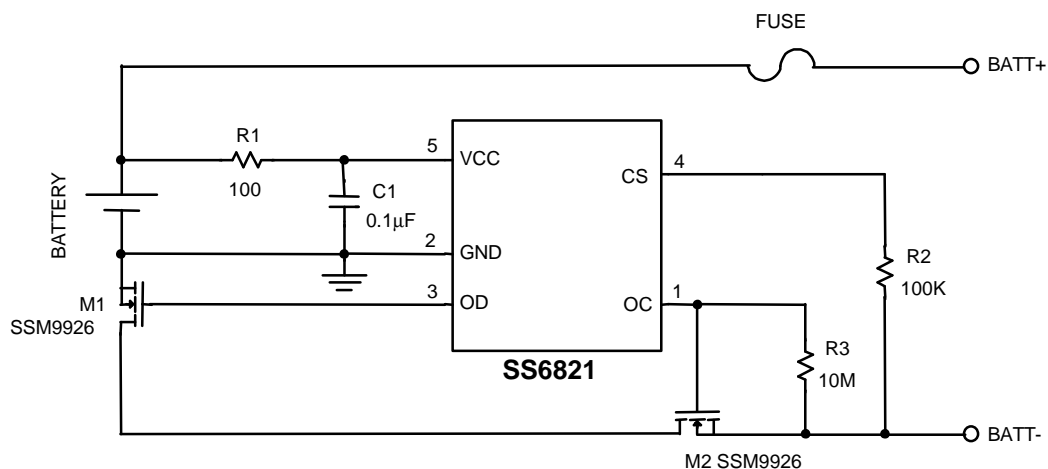
Protection IC for single-cell Lithium-Ion battery packs.

DESCRIPTION

The SS6821 battery protection IC is designed to protect a lithium-ion battery from damage or reduced lifetime due to over-charge, over-discharge, and/or over-current in single-cell lithium-ion battery powered systems, such as cellular phones. The ultra-small package and few external components make the SS6821 ideal for integration into the limited space of a battery pack.

The accurate $\pm 50\text{mV}$ over-charging detection voltage ensures safe and full-utilization charging. Four different specification values for over-charge protection voltage are provided for various protection requirements. The very low standby current drains little current from the cell while in storage.

TYPICAL APPLICATION CIRCUIT



Protection Circuit for Single-Cell Lithium-Ion Battery

ORDERING INFORMATION

SS6821-XCXXX

 Packing:
 TR: Tape and reel

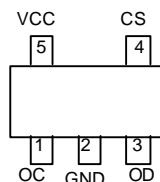
 Package type
 V: SOT-23-5

 Overcharge protection:
 A: 4.35V
 B: 4.30V
 C: 4.25V
 D: 4.20V

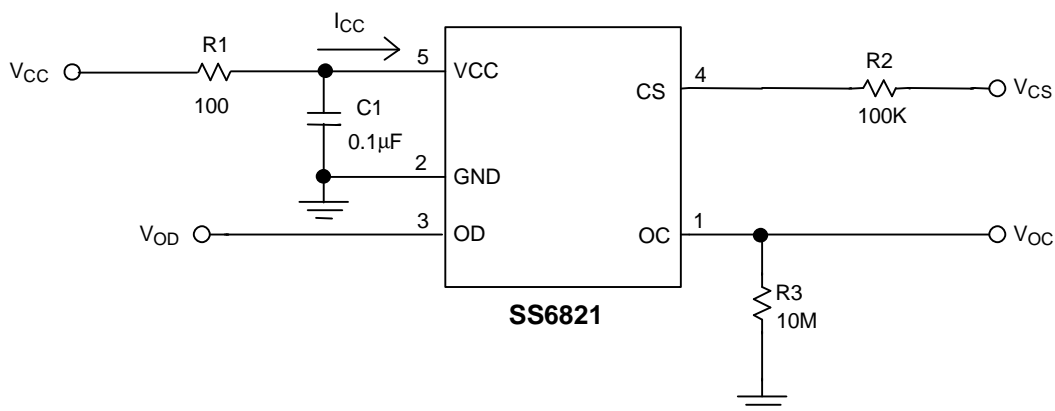
Example: SS6821-ACVTR

 → 4.35V version, in SOT-23-5 package
 shipped in tape and reel

PIN CONFIGURATION

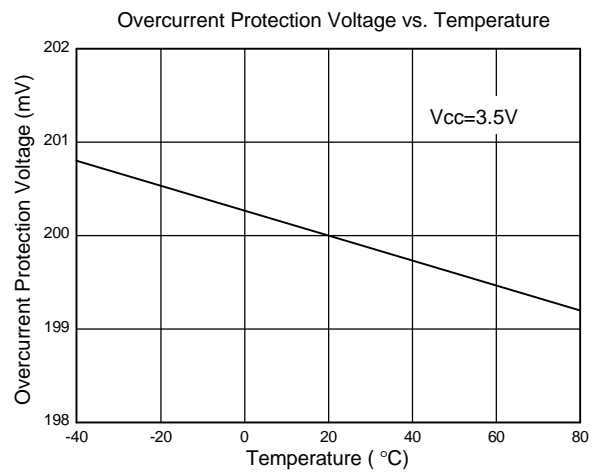
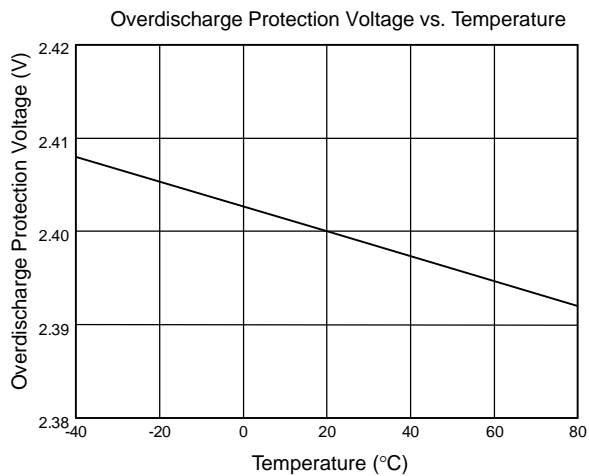
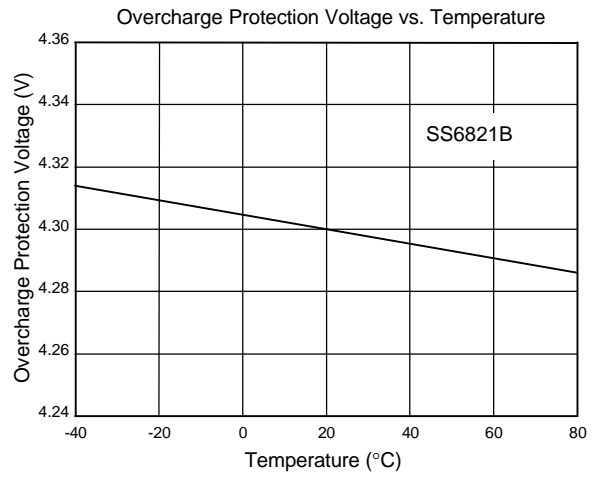
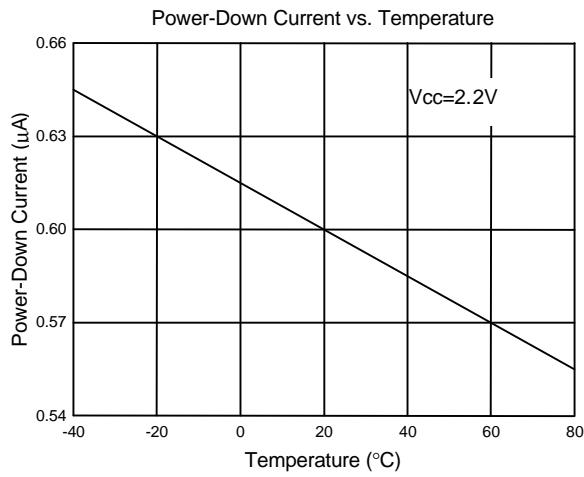
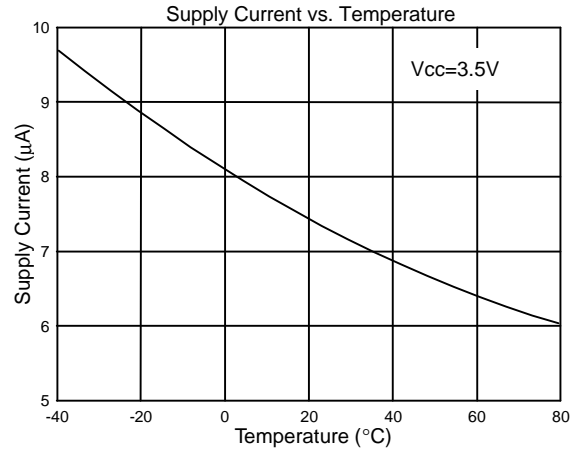
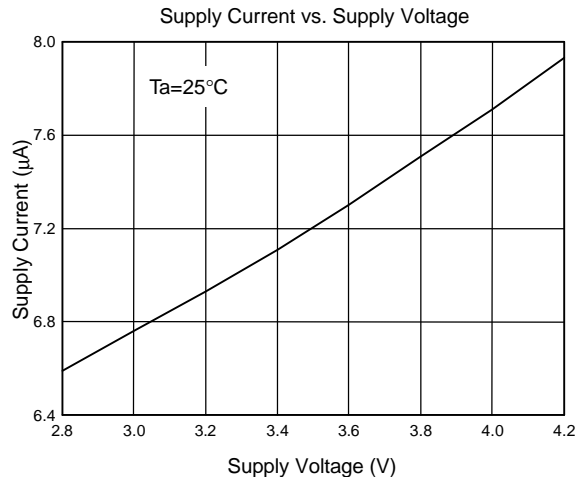
 SOT-23-5
 TOP VIEW

ABSOLUTE MAXIMUM RATINGS

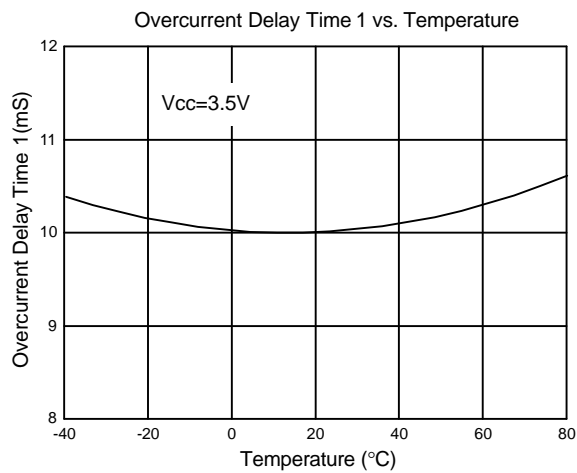
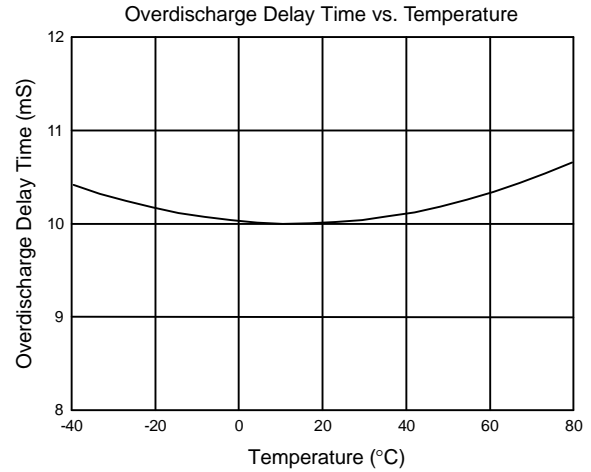
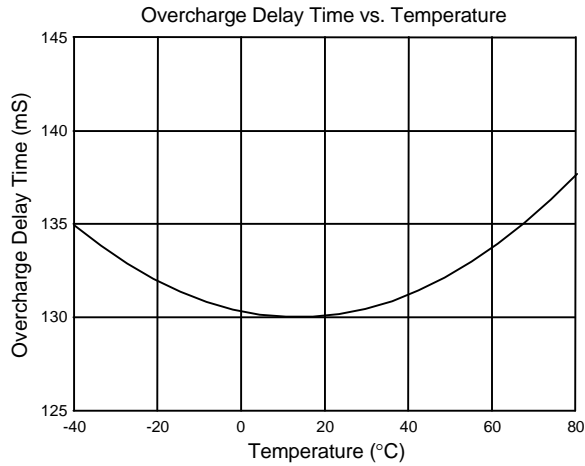
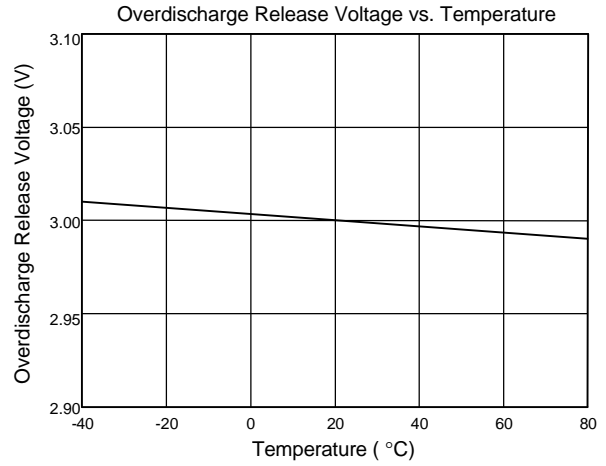
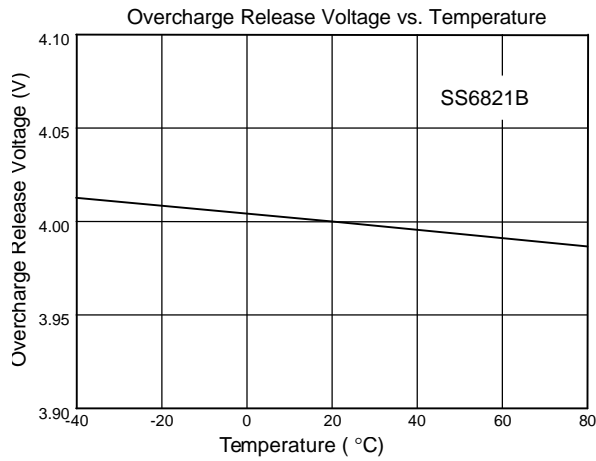
Supply Voltage.....	18V
DC Voltage Applied on other Pins	18V
Charger Voltage	14V
Operating Temperature Range	-40°C~85°C
Storage Temperature Range	- 65°C~125°C

TEST CIRCUIT


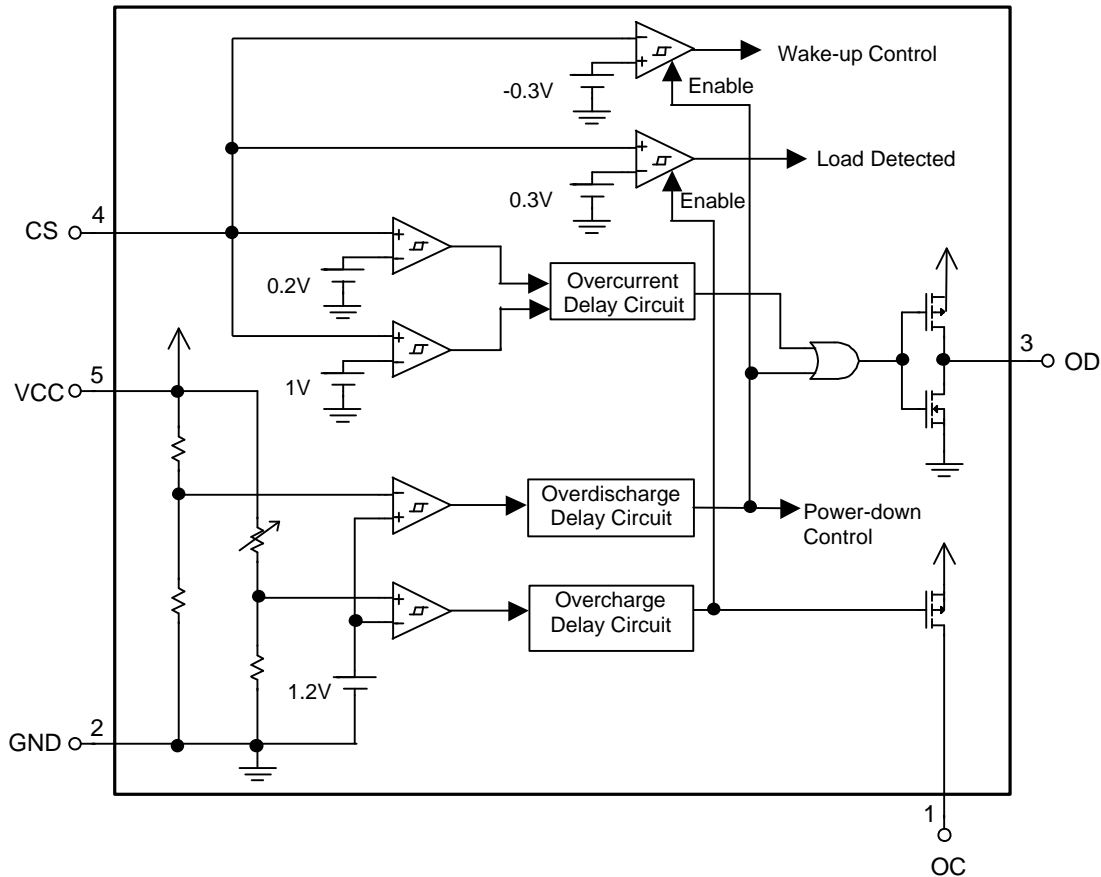
ELECTRICAL CHARACTERISTICS (Ta=25°C, unless otherwise specified.)

PARAMETER	TEST CONDITIONS	SYMBOL	MIN.	TYP.	MAX.	UNIT
Supply Current	V _{CC} =3.5V	I _{CC}		7	11	μA
Power-Down Current	V _{CC} =2.2V,	I _{PD}		0.6	1.0	μA
Over-charge Protection Voltage	SS6821A	V _{OCP}	4.30	4.35	4.40	V
	SS6821B		4.25	4.30	4.35	
	SS6821C		4.20	4.25	4.30	
	SS6821D		4.15	4.20	4.25	
Over-charge Hysteresis Voltage		V _{HYS}	230	300	370	mV
Over-discharge Protection Voltage		V _{ODP}	2.25	2.4	2.55	V
Over-discharge Release Voltage		V _{ODR}	2.85	3.0	3.15	V
Over-current Protection Voltage	V _{CC} =3.5V	V _{OIP}	180	200	220	mV
Over-charge Delay Time	V _{CC} =V _{OCP} -0.1→ V _{OCP} + 0.1V	T _{OC}	100	150	200	ms
Over-discharge Delay Time	V _{CC} = 2.6V → 2.2V	T _{OD}	6	12	18	ms
Over-current Delay Time (1)	V _{CC} =3.5V, 1V>V _{CS} >0.2V	T _{OI1}	6	12	18	ms
Over-current Delay Time (2)	V _{CC} =3.5V, V _{CS} >1V	T _{OI2}			50	μs
OD Pin Output "H" Voltage		V _{DH}	V _{CC} -0.2	V _{CC} -0.02		V
OD Pin Output "L" Voltage		V _{DL}		0.01	0.1	V
Load Detection Threshold Voltage	V _{CC} =V _{OCP} - 50mV	V _{LD}		0.3	0.4	V
Charge Detection Threshold Voltage	V _{CC} =2.4V	V _{CH}	-0.45	-0.3		V

TYPICAL PERFORMANCE CHARACTERISTICS


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)


BLOCK DIAGRAM



PIN DESCRIPTIONS

- PIN 1: OC** - PMOS open drain output for control of the charge control MOSFET M2. In normal mode, this PMOS turns on to pull the gate of the MOSFET M2 high, and the MOSFET M2 turns on. When over-charge occurs, this PMOS turns off, no current flows through R3 and the MOSFET M2 turns off.
- PIN 2: GND** - Ground pin. This pin is to be connected to the negative terminal of the battery cell.
- PIN 3: OD** - Output pin for control of the discharge control MOSFET M1. When over-discharge occurs, this pin goes low to turn off the

MOSFET M1 and discharging is halted.

- PIN 4: CS** - Input pin for current sensing. Using the sum of the drain-source voltages of the MOSFET M1 and the MOSFET M2 (voltage between CS and GND), it senses the discharge current during normal mode and detects whether charging current is present during the power-down mode. It is also used to detect whether the load is connected during over-charge mode.

- PIN 5: VCC** - Power supply pin. This pin is to be connected to the positive terminal of the battery cell.

APPLICATION INFORMATION

OPERATION

Over-charge Protection

When the voltage of the battery cell exceeds the overcharge protection voltage (V_{OCP}) for longer than the overcharge delay time (T_{OC}) period, charging is halted by turning off the charge control MOSFET M2. The overcharge delay time is fixed to 100ms by circuitry internal to the IC. The over-charge condition is released in one of two ways:

1. The voltage of the battery cell becomes lower than the over-charge release voltage (V_{OCR} or $V_{OCP} - V_{HYS}$) through self-discharge.
2. The voltage of the battery cell falls below the over-charge protection voltage (V_{OCP}) because a load has been connected.

When the battery voltage is above V_{OCP} , the over-charge condition is never released even if a load is connected to the pack.

Over-discharge protection

When the voltage of the battery cell goes below the over-discharge protection voltage (V_{ODP}) for longer than the over-discharge delay time (T_{OD}) period, discharging is halted by turning off the discharge control MOSFET M1. The over-discharge delay time defaults to 10ms. Discharging is immediately resumed when the voltage of the battery cell becomes higher than over-discharge release voltage (V_{ODR}) through charging.

Over-current protection

In normal mode, the SS6821 continuously monitors the discharge current by sensing the voltage of the CS pin. If the voltage of the CS pin exceeds the over-current protection voltage (V_{OIP}) for longer than the over-current delay time (T_{OI}) period, the over-current protection circuit operates and discharging is halted by

turning off of the discharge control MOSFET M1. The over-current condition returns to the normal mode when the load is released and the impedance between the BATT+ and BATT- terminals is $1M\Omega$ or higher.

The SS6821 is provided with two over-current detection levels (0.2V and 1V) and two over-current delay times (T_{OI1} and T_{OI2}) corresponding to each over-current detection level.

Load detection after overcharge

The load detection function after over-charge is implemented by detecting the CS pin voltage. Once a load is connected to the battery pack after an over-charge, discharge current flows through the parasitic diode of MOSFET M2 and there is a diode voltage drop between CS and GND. A load is determined to be connected to the pack if the CS pin voltage is above the load detection threshold voltage (V_{LD}).

Power-down after over-discharge

When an over-discharge occurs, the SS6821 will go into power-down mode, turning off all the timing generation and detection circuitry to reduce the quiescent current to $0.6\mu A$ ($V_{CC}=2.2V$). At the same time, the CS pin is pulled high to VCC through a high resistance resistor.

Charge detection after over-discharge

When over-discharge occurs, the discharge control MOSFET M1 turns off and discharging is halted. However, charging is still permitted through the parasitic diode of M1. Once the charger is connected to the battery pack, the SS6821 immediately turns on all the timing generation and detection circuitry. Charging is determined to be in progress if the voltage between CS and GND is below the charge detection threshold voltage (V_{CH}).

DESIGN GUIDE

Selection of external control MOSFETs

Because the over-current protection voltage is pre-set, the threshold current for over-current detection is determined by the on-resistance of the discharge control MOSFET M1. The required on-resistance of the external control MOSFETs can be determined by the equation: $R_{ON} = V_{OIP} / (2 \times I_T)$ (I_T is the over-current threshold current). For example, if the over-current threshold current I_T is designed to be 3A, the on-resistance of the external control MOSFETs must be 33m Ω . Users should be aware that on-resistance of the MOSFET changes with temperature variation due to heat dissipation. It changes with the voltage between gate and source as well. (On-resistance of a MOSFET increases as the voltage between gate and source decreases).

Once the on-resistance of the external MOSFET changes, the over-current threshold current will change accordingly.

Suppressing the ripple and disturbance from the charger

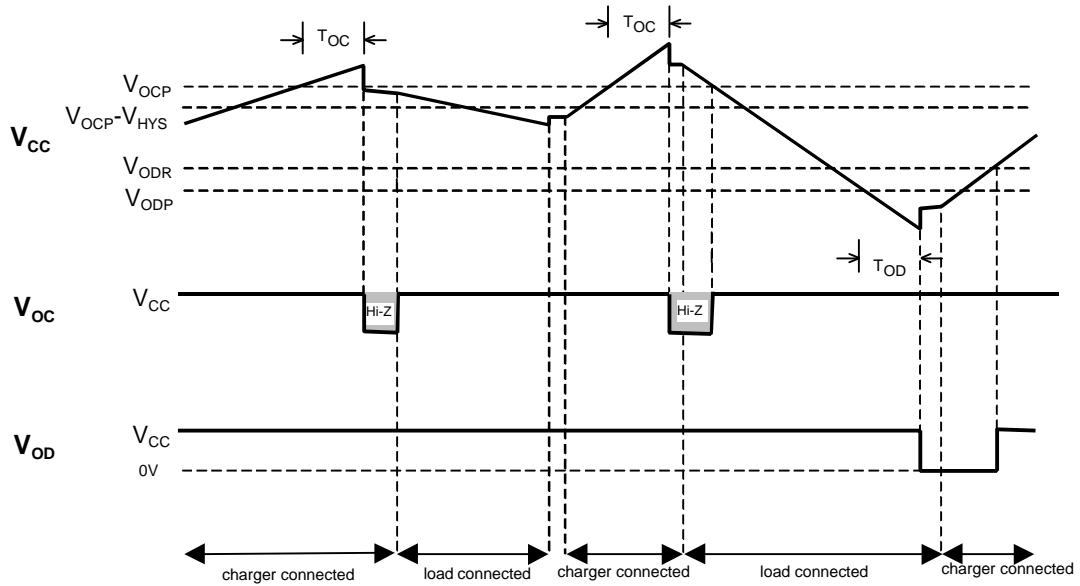
To suppress the ripple and disturbance from the charger, connecting R1, C1 to the VCC pin is recommended.

Protection at CS pin

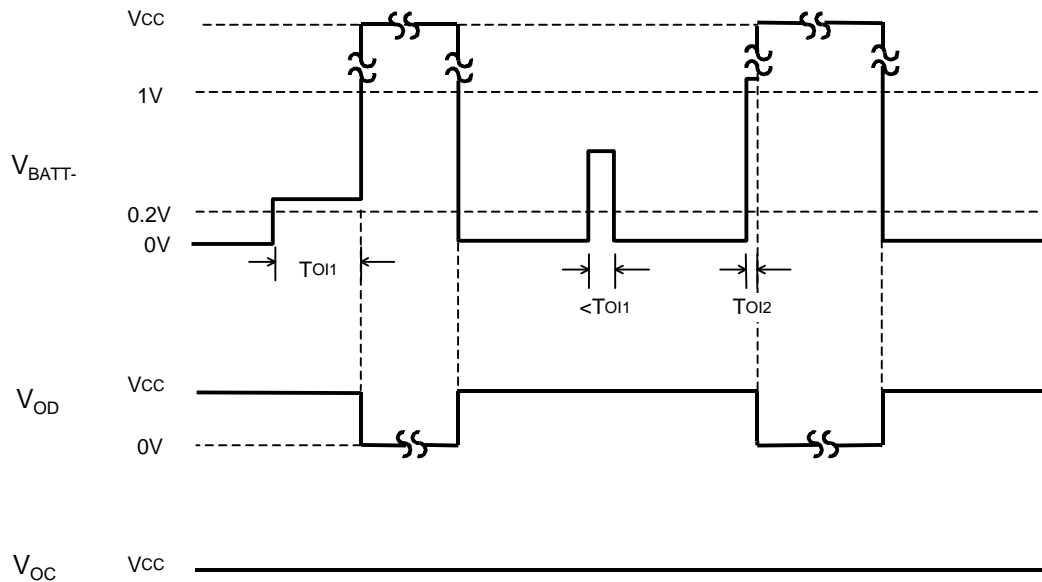
R2 is used for latch-up protection when the charger is connected under an over-discharge condition, and over-stress protection for accidental reverse-connection of the charger. A larger value of R2 reduces the charger leakage current in over-charge mode, but may possibly disable the charge detection function after over-discharge. A resistance value of 100K Ω is recommended.

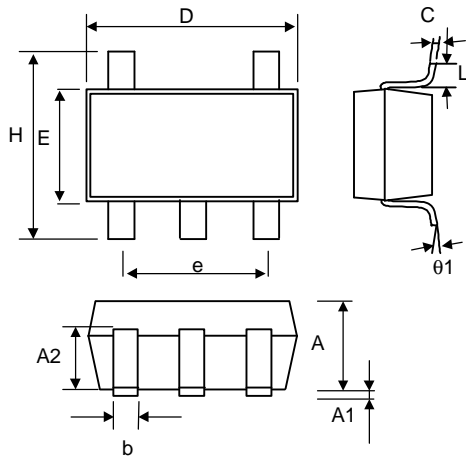
TIMING DIAGRAMS

- Over-charge and over-discharge protection



- Over-current protection ($V_{CC}=3.5V$)



PHYSICAL DIMENSIONS
SOT-23-5 (unit: mm)


SYMBOL	MIN	MAX
A	1.00	1.30
A1	—	0.10
A2	0.70	0.90
b	0.35	0.50
C	0.10	0.25
D	2.70	3.10
E	1.40	1.80
e	1.90 (TYP)	
H	2.60	3.00
L	0.37	—
θ1	1°	9°

SOT-23-5 MARKING

Part No.	Marking
SS6821ACV	BL0A
SS6821BCV	BL0B
SS6821CCV	BL0C
SS6821DCV	BL0D

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