



AF3209

2-In-1 Single-Cell Li-ion Battery Protection IC

➤ Description

AF3209 is a 2-In-1 single-cell lithium battery protection chip with built-in MOSFET. This chip features ultra-low power consumption and low on-resistance integrated MOSFET. It provides comprehensive protection functions including charge over-voltage protection, charge over-current protection, discharge over-current protection, over-temperature protection and short-circuit protection, ensuring safe and efficient operation of the battery cell.

AF3209 adopts the SOT23-5 package, requiring only one external resistor and one capacitor, making the application circuit extremely simple, safe and reliable.

➤ Applications

- Single-cell rechargeable lithium-ion battery packLi-ion Battery Protection Module
- Li-ion Battery Applications

➤ Features

- Integrated 16mΩ Power Tube
- VOC Protection Threshold: 4.3V±50mV
- VOC Recovery Threshold: 4.15V±60mV
- VOD Protection Threshold: 2.5V±100mV
- VOD Recovery Threshold: 3.0V±100mV
- IOC Protection Threshold: 10A
- IOD Protection Threshold: 11.5A
- Short Protection Threshold: 25A
- Built-in over-temperature protection
- Triple over-discharge detection protection
- Ultra-low quiescent current: 3.5 μA
- Ultra-low sleep current: 0.6 μA
- 0V Lithium Battery Charging Allows Function
- Lead-free product compliant with European RoHS standard

➤ Device Information

AF 3209 T S5

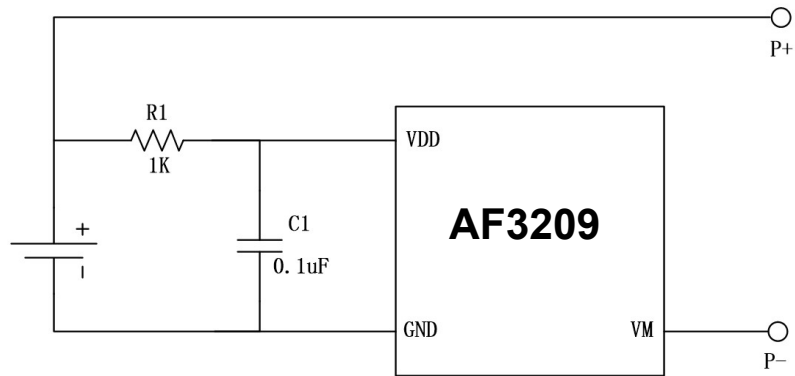
① ② ③ ④

①	Standard
②	Product Name
③	T : V _{OC} =4.300V, V _{OCR} =4.150V V _{OD} =2.500V, V _{ODR} =3.000V
④	S5 : SOT23-5 package

➤ Marking Information

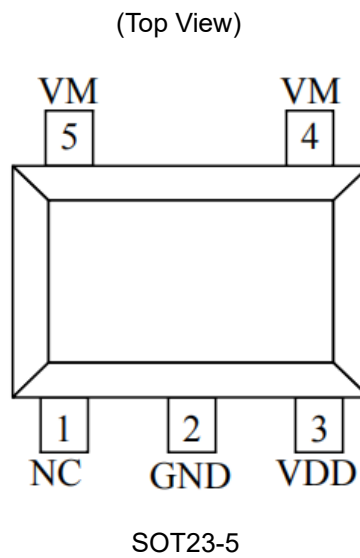
Device	Ordering Number	V _{OC} /V _{OCR} (V)	V _{OD} /V _{ODR} (V)	Marking	Package	Quantity	Packing
AF3209	AF3209TS5	4.30/4.15	2.50/3.00	AF3209	SOT23-5	3000pcs	Tape and Reel

➤ Typical Application^(Note 1)



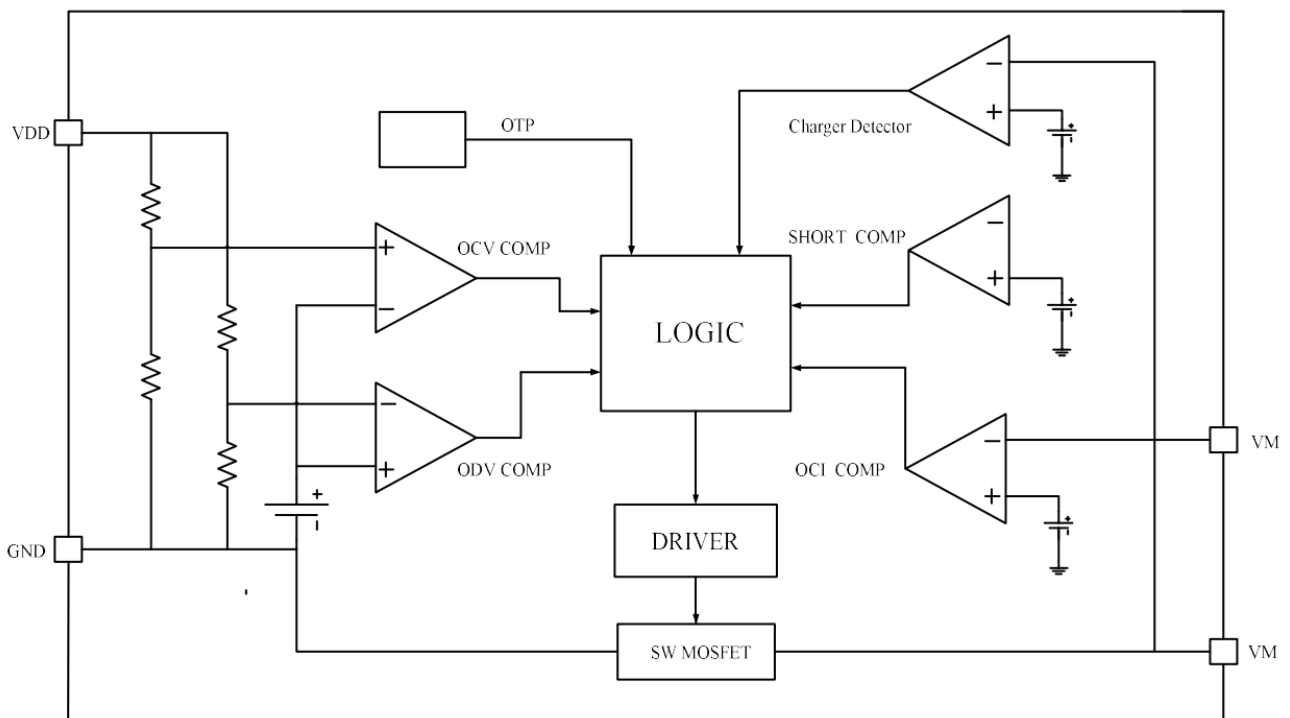
Note 1: The recommended resistance value for resistor R1 is 1kΩ–2kΩ, and the recommended capacitance value for capacitor C1 is 0–1μF. After connecting to the battery cell, the chip can be automatically activated and operate normally. If the battery needs to be spot-welded, resistor R1 must be 1kΩ.

➤ PIN Configuration



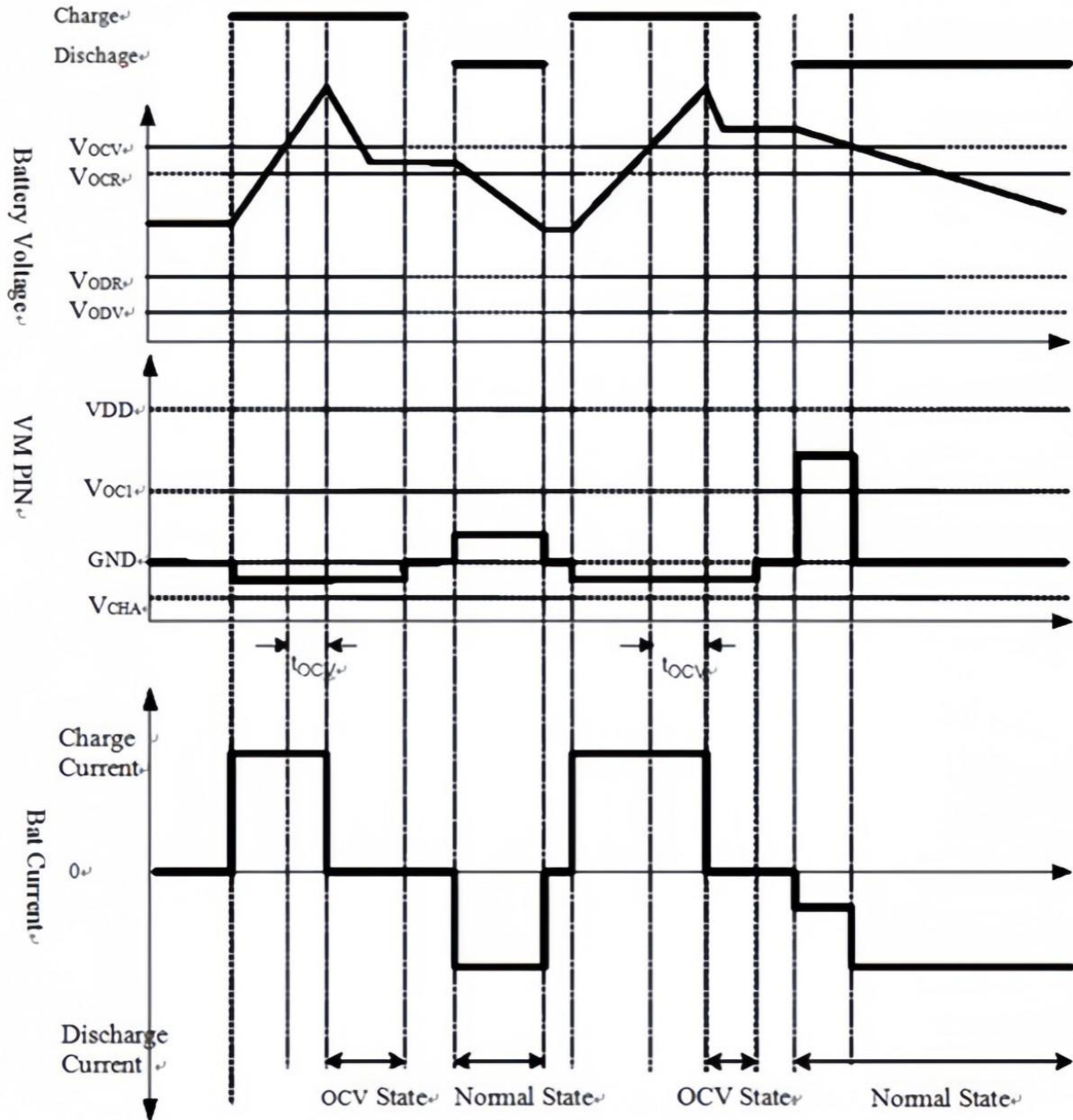
➤ Pin Description

Pin Name	Pin No.	Pin Function
NC	1	No connected.
GND	2	Chip ground, connected to the negative terminal of the battery cell.
VDD	3	Power supply.
VM	4,5	Charger negative voltage input.

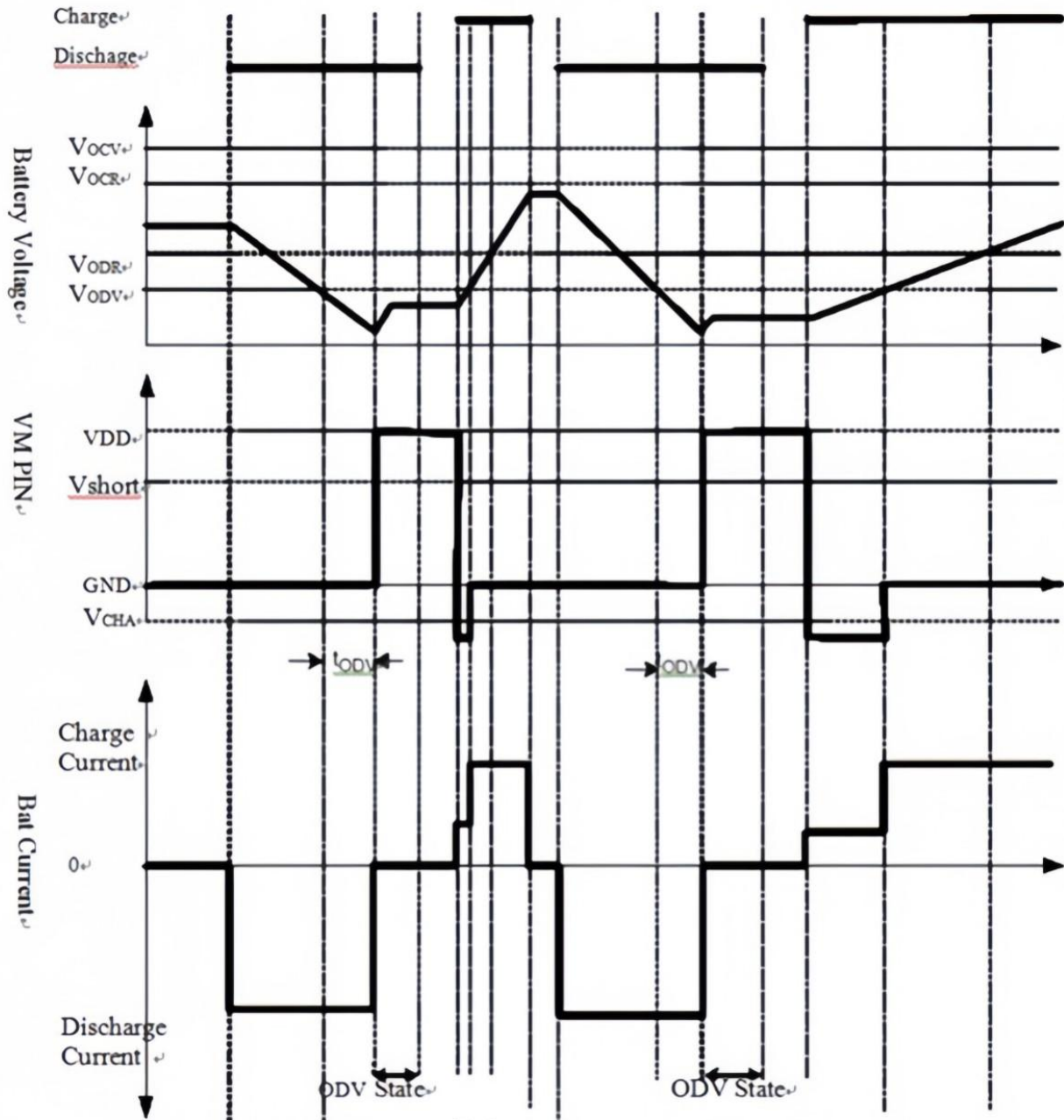
➤ Block Diagram


➤ Working Timeline Diagram

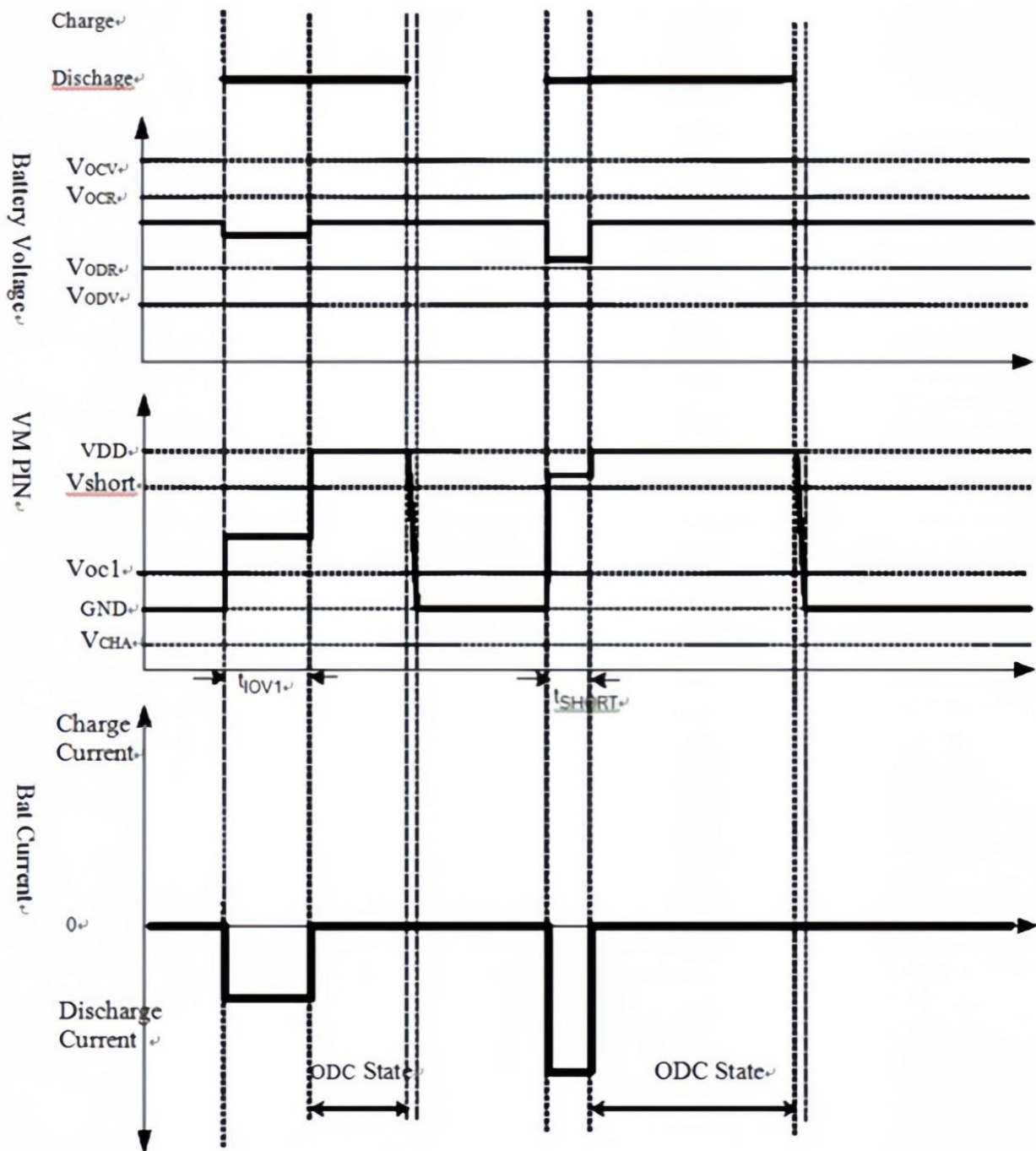
Overcharge → Discharge → Normal operation



Over-discharge → Charging → Normal operation



Discharge overcurrent → Normal operation





➤ **Absolute Maximum Ratings** (Note 1)

Symbol	Pin	Description	Parameter Range	Unit
VDD	3	Supply Voltage	-0.3 ~8	V
VM	4,5	Charger Input Voltage	-8 ~10	V
TSTG		Storage Temperature Range	-55 ~ 145	°C
TJ		Junction Temperature	-40 ~ 145	°C
PMAX		Power Dissipation at T=25°C	400	mW
HBM		ESD	4	KV

Note 1: Operating any parameter beyond the absolute maximum ratings may result in permanent damage to the chip. The ratings given are only the extreme limits; operation under these conditions does not ensure the chip's technical specifications will be met. Prolonged operation near the absolute maximum ratings may impair the reliability of the chip.

➤ **Electronics Characteristics** (Unless otherwise specified, $T_A=25^\circ\text{C}$, $V_{DD}=3.6\text{V}$)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Supply Voltage	V_{VDD}		0		6	V
Charger Input Voltage	VM		-6		6	V
Over-charge Protection Threshold	V_{OCV}	$V_{P+~P-}=5\text{V}$, Current limit 0.1A;VBAT from 3.6V to 4.5V	4.25	4.3	4.35	V
Over-charge Recovery Threshold	V_{OCR}	$V_{P+~P-}=5\text{V}$, Current limit 0.1A;VBAT from 4.5V to 3.6V	4.09	4.15	4.21	V
Over-discharge Protection Threshold	V_{OD}	$V_{P+~P-}=5\text{V}$, Current limit 0.1A;VBAT from 3.6V to 2.0V	2.4	2.5	2.6	V
Over-discharge Recovery Threshold	V_{ODR}	$V_{P+~P-}=5\text{V}$, Current limit 0.1A;VBAT from 2.0V to 3.6V	2.9	3	3.1	V
Discharge Over-current Threshold	I_{IOD1}	$V_{BAT}=3.8\text{V}$, Current increases from 0A	9	11.5	14	A
Load Short-Circuit Threshold	I_{SHT}		15	25	35	A
Charge Over-current Threshold	I_{IOC}	$V_{VDD}=3.8\text{V}$, Current increases from 0A	7	10	13	A
Operating current	IOPE	Leave VM floating		3.5	7	μA
Sleep current	IPDN	VDD=1.8V		0.6	1.5	μA
Pull-up and pull-down current	IPU			14		μA



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Internal pull-up current	IPD	VM=1V		14		μA
Resistance from VM to GND	RDS(ON)	IVM=1A	12.5	16	18	m Ω
Over-temperature protection detection temperature	TSHD			145		$^{\circ}\text{C}$
Over-temperature protection release temperature	TSHR			120		$^{\circ}\text{C}$
VOC Protection Delay Time	T _{VOC}			100		ms
VOC Recovery Delay Time	T _{VOCR}			100		ms
VOD Protection Delay Time	T _{VOD}			8		ms
	T _{IOV2}			2		ms
Short-circuit Protection Delay Time	T _{IOV2}			2		ms
Short-circuit Recovery Delay Time	T _{SHTR}			150		μs



➤ Functional Description

AF3209 monitors the battery voltage and current, and protects a single-cell rechargeable lithium battery from damage caused by overcharge voltage, over-discharge voltage, over-discharge current, and short-circuit conditions by disconnecting the charger or the load. These features ensure that the rechargeable battery operates within specified limits. The chip requires only one external capacitor and one external resistor; the MOSFET is integrated internally, with a typical equivalent resistance of 16 mΩ.

The AF3209 supports four operating modes: normal operation mode, charge operation mode, discharge operation mode, and sleep mode.

Normal Operation Mode

If no abnormal conditions are detected, the charging and discharging processes can switch freely; this state is referred to as normal operation mode.

Overcharge Voltage Condition

During charging under normal conditions, when the battery voltage exceeds the overcharge detection voltage (VOCV) and persists for a duration equal to or longer than the overcharge voltage detection delay time (TOCV), the AF3209 will control the MOSFET to stop charging. This state is referred to as the overcharge voltage condition. If the abnormal condition disappears within the overcharge voltage detection delay time (TOCV), the system will not take action.

The overcharge voltage condition is released under the following two circumstances:

1. When the charger is connected, the voltage at the VM pin falls below the charger detection voltage (VCHA), and the battery voltage drops to the overcharge release voltage (VOCR).
2. When the charger is not connected, the battery voltage drops to the overcharge detection voltage (VOCV). If the charger is not connected and the battery voltage remains higher than the overcharge detection voltage, the battery will be discharged through the internal diode.

Over-Discharge Voltage Condition

During discharge under normal conditions, when the battery voltage drops to the over-discharge detection voltage (VODV) and persists for a duration equal to or longer than the over-discharge voltage detection delay time (TODV), the AF3209 will disconnect the battery from the load to stop discharging. This state is referred to as the over-discharge voltage condition. At this point, the discharge control MOSFET is turned off, and the internal pull-up current source is enabled. When the VDD voltage drops to 2.3V (typical) or lower, the current consumption is reduced to the sleep state current consumption (IPDN). This state is referred to as the sleep condition. When the VDD voltage reaches 2.4V (typical) or higher, the sleep condition is released. When the battery voltage rises to or above the over-discharge release voltage (VODR), the AF3209 returns to the normal operating condition.

Over-Discharge Current Condition

If the discharge current exceeds the rated value (detection thresholds for over-discharge current 1 and over-



discharge current 2) and the duration is equal to or longer than the over-discharge current detection delay time, the battery will be disconnected from the load. If the current drops back within the rated range before the over-discharge current detection delay time elapses, the system will not take action. The internal pull-down current pulls down the VM pin. When the voltage at the VM pin drops to or below the reference voltage for over-discharge current 1, the over-discharge current condition is reset.

Load Short-Circuit Current Condition

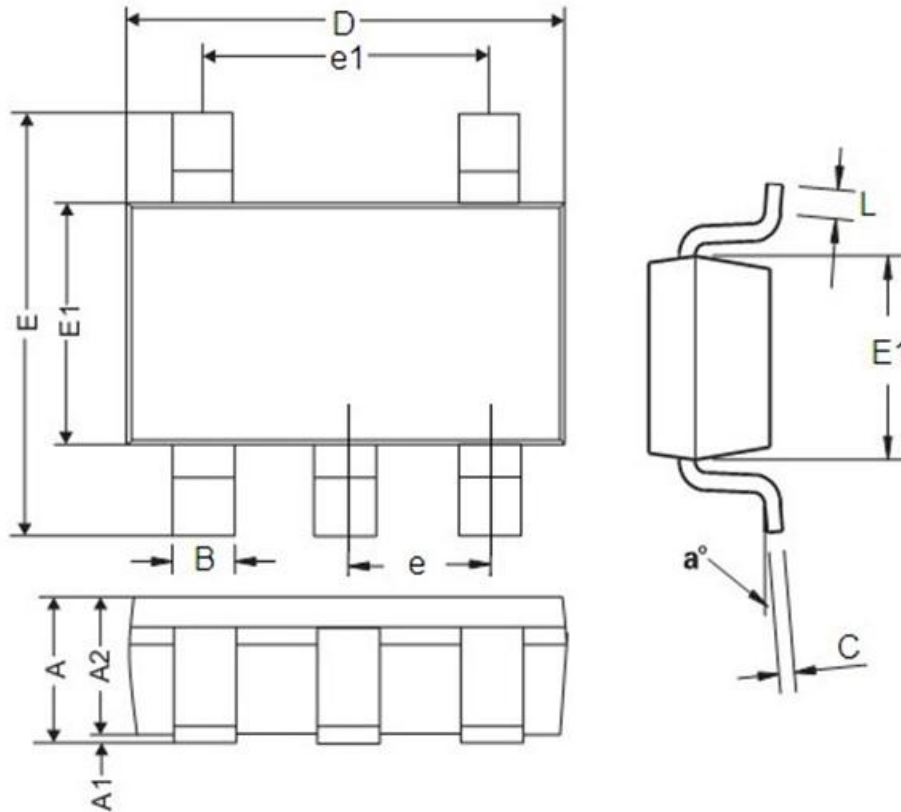
If the voltage at the VM pin drops to or below the short-circuit protection voltage (VSHORT), the system will stop discharging, and the battery will be disconnected from the load. TSHORT is the maximum delay time for current interruption. When the voltage at the VM pin drops to or below the reference voltage for over-discharge current, the load short-circuit condition is reset.

Charger Detection

When a battery in the over-discharge state is connected to a charger, and the voltage at the VM pin drops to or below the charger detection voltage (VCHA), the AF3209 will release the over-discharge state once the battery voltage rises to or above the over-discharge detection voltage (VODV).

0V Charging

0V charging is supported. When the battery voltage is below 2.3V, the charging chip enters the sleep state. At this time, the MOSFET is turned off, and the chip charges through the body diode. When the battery voltage is below 2.3V, the charging current must not exceed 500mA to prevent damage to the battery and the chip.

➤ **Package Information**
SOT23-5


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	MAX.	MIN.	Max.
A	1.05	0.45	0.0413	0.057
A1	0	1.15	0	0.0059
A2	0.9	1.3	0.0354	0.0511
B	0.25	0.5	0.0098	0.0196
C	0.1	0.23	0.0039	0.009
D	2.82	3.05	0.111	0.12
E	2.6	3.05	0.1023	0.12
E1	1.5	1.75	0.059	0.0688
e	0.95 (TYP)		0.0374 (TYP)	
e1	1.90 (TYP)		0.0748 (TYP)	
L	0.1	0.6	0.0039	0.0236
θ	0°	30°	0°	30°



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