GENERAL DESCRIPTION

The FH8609A2 product is a high integration solution for lithium-ion/polymer battery protection. FH8609A2 contains advanced power MOSFET, high-accuracy voltage detection circuits and delay circuits. FH86AJ is put into an ultra-small SOT23-5 package and only one external component makes it an ideal solution in limited space of battery pack.

FH8609A2 has all the protection functions required in the battery application including overcharging, over-discharging, overcurrent and load short circuiting protection etc. The accurate overcharging detection voltage ensures safe and full utilization charging. The low standby current drains little current from the cell while in storage.

The device is not only targeted for digital cellular phones, but also for any other Li-Ion and Li-Poly battery-powered information appliances requiring long-term battery life.

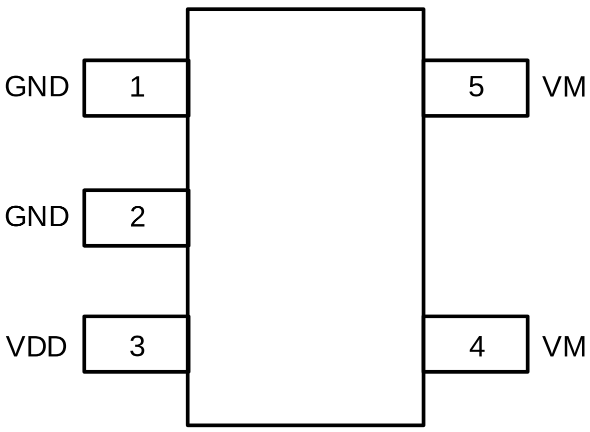
FEATURES

- Protection of Charger Reverse Connection
- Protection of Battery Cell Reverse Connection Without External Load
- Integrated Advanced Power MOSFET with Equivalent of 16.5 mΩ $R_{SS(ON)}$
- Ultra-small SOT23-5 Package
- Only One External Capacitor Require
- Over-temperature Protection
- Overcharge Current Protection
- Two-step Overcurrent Detection
  - -Overdischarge Current 1
  - -Load Short Circuiting
- Low Current Consumption
  - -Operation Mode: 3.9μA typ
  - -Power-down Mode:2.2μA typ
- Charger Detection Function
- 0V Battery Charging Function
- Delay Times are generated inside
- High-accuracy Voltage Detection
- RoHS Compliant and Lead (Pb) Free

APPLICATIONS

One-Cell Lithium-ion Battery Pack
Lithium-Polymer Battery Pack
Power Bank

PIN CONFIGURATION



TOP View

Figure 1. PIN Configuration

PIN DESCRIPTION

FH8609A2 PIN NUMBER	PIN NAME	PIN DESCRIPTION
1,2	GND	Ground, connect the negative terminal of the battery to this pin
3	VDD	Power Supply
4,5	VM	The negative terminal of the battery pack. The internal FET switch connects this terminal to GND

■ Typical Application

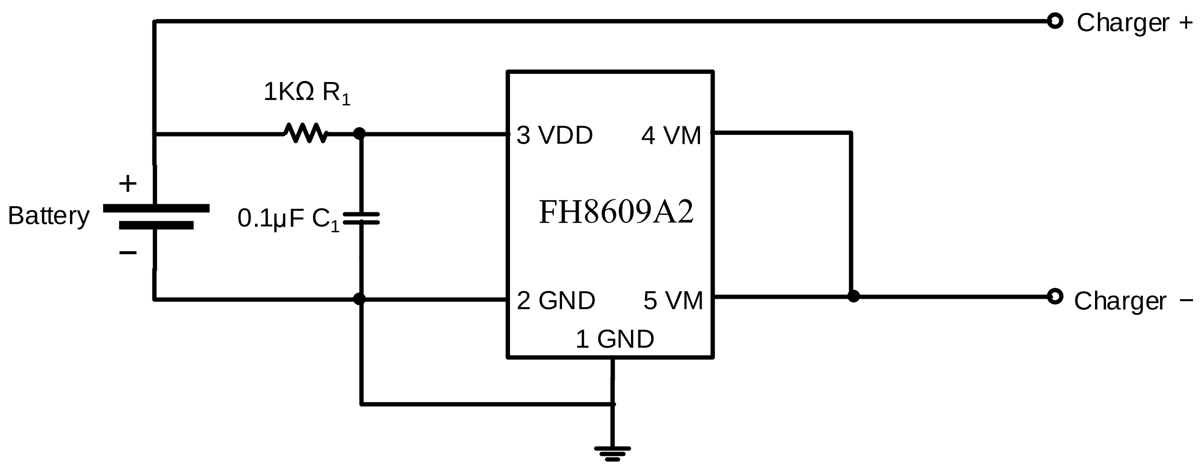


Figure 1. Basic Application Circuit

ABSOLUTE MAXIMUM RATINGS

(NOTE: DO NOT EXCEED THESE LIMITS TO PREVENT DAMAGE TO THE DEVICE. EXPOSURE TO ABSOLUTE MAXIMUM RATING CONDITIONS FOR LONG PERIODS MAY AFFECT DEVICE RELIABILITY.)

PARAMETER	VALUE	UNIT
VDD input pin voltage	-0.3 to 6	V
VM input pin voltage	-6 to 10	V
Operating Ambient Temperature	-40 to 85	°C
Maximum Junction Temperature	150	°C
Storage Temperature	-55 to 150	°C
Lead Temperature (Soldering, 10 sec)	300	°C
Power Dissipation at T=25°C	0.4	W
Package Thermal Resistance (Junction to Ambient) θ_{JA}	250	° C/W
Package Thermal Resistance (Junction to Case) θ_{JC}	130	° C/W
HBM ESD	2000	V

ELECTRICAL CHARACTERISTICS

Typical and limits appearing in normal type apply for TA = 25˚C, unless otherwise specified.

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Detection Voltage						
Overcharge Detection Voltage	V_{CU}		4.25	4.30	4.35	V
Overcharge Release Voltage	V_{CL}		4.00	4.10	4.20	V
Overdischarge Detection Voltage	V_{DL}		2.3	2.4	2.5	V
Overdischarge Release Voltage	V_{DR}		2.9	3.0	3.1	V
Detection Current						
Overdischarge Current Detection	*I_{IOV1}	V_{DD}=3.6V	6	9	12	A
Overdischarge Current Recovery	*I_{ROV1}	V_{DD}=3.6V	8.5	25	40	μA
Overcharge Current Detection	*I_{CHOC}	V_{DD}=3.6V	4	6	8	A
Load Short-Circuiting Detection	*I_{SHORT}	V_{DD}=3.6V	20	35	60	A
Current Consumption						
Current Consumption in Normal Opera- tion	I_{OPE}	V_{DD}=3.6V VM pin floating		3.9	6	μA
Current Consumption in Power Down	I_{PD}	V_{DD}=3.6V VM pin floating		2.2	4	μA
VM Internal Resistance						
Internal Resistance between VM and V	R_{VMD}	V_{DD}=3.6V V_M=1.0V	200	300	400	kΩ
Internal Resistance between VM and GND	R_{VMS}	V_{DD}=3.6V VM pin floating	15	25	35	kΩ
FET on Resistance						
Equivalent FET on Resistance	*Rss(on)	V_{DD}=3.6V I_{VM}=1.0A		16.5	25	mΩ
Over Temperature Protection						
Over Temperature Protection	*T_{SHD+}			150		˚C
Over Temperature Recovery Degree	*T_{SHD-}			110		˚C
Detection Delay Time						
Overcharge Voltage Detection Delay- Time	t_{CU}		80	130	180	mS
Overdischarge Voltage Detection Delay Time	t_{DL}		20	40	60	mS
Overdischarge Current1 Detection De- lay Time	t_{IOV1}	V_{DD}=3.6V	4	8	18	mS
Overcharge Current Detection Delay Time	*t_{CHOC}	V_{DD}=3.6V	5	10	20	mS
Load Short-Circuiting Detection De- lay Time	*t_{SHORT}	V_{DD}=3.6V	50	300	600	μS

Note1: * The parameter is guaranteed by design.

FUNCTIONAL BLOCK DIAGRAM

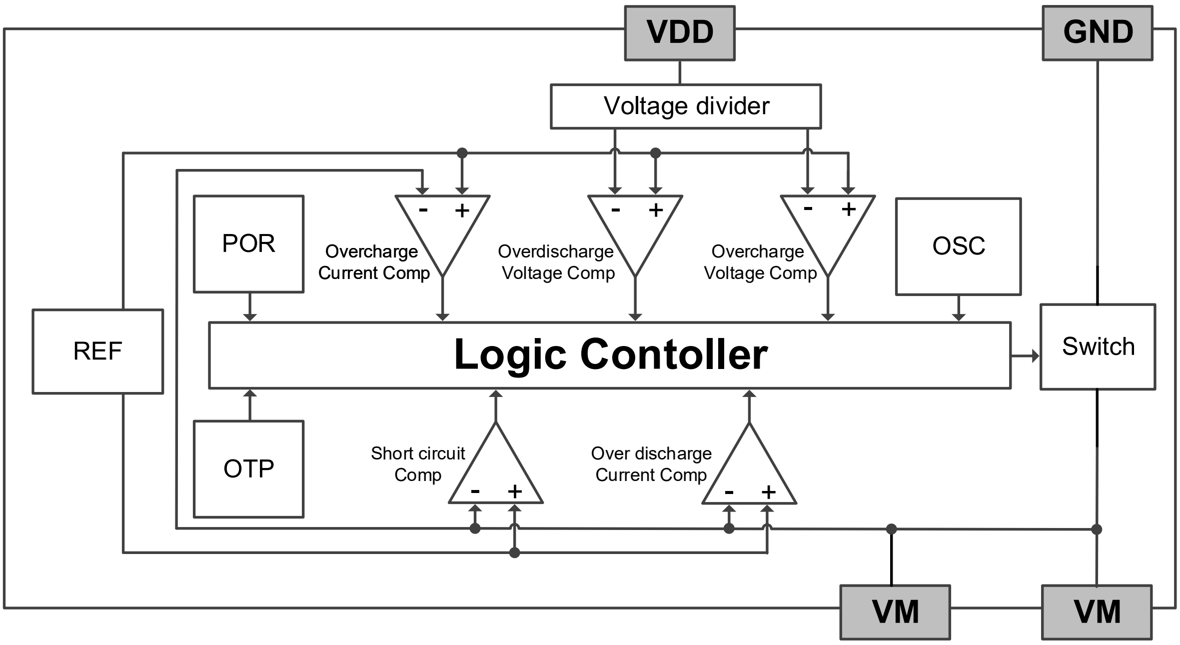


Figure 3. Functional Block Diagram

FUNCTIONAL DESCRIPTION

The FH8609A2 monitors the voltage and current of a battery and protects it from bei ng damaged due to overcharge voltage, ov erdischarge voltage, overdischarge current, and short circuit conditions by disconnectin g the battery from the load or charger. The se functions are required in order to operat e the battery cell within specified limits.The device requires only one external capacito r. The MOSFET is integrated and its $R_{SS(ON)}$ is as low as 16.5mΩ typical.

Normal Mode

If no exception condition is detected, ch arging and discharging can be carried out freely. This condition is called the normal o perating mode.

Overcharge Condition

When the battery voltage becomes highe r than the overcharge detection voltage (V_{CU}) during charging under normal conditio n and the state continues for the overcharg e detection delay time (t_{CU}) or longer, the FH8609A2 turns the charging control FET off to stop charging. This condition is called th e overcharge condition. The overcharge co ndition is released in the following two case s:

1. When the battery voltage drops below the overcharge release voltage (V_{CL}), the F H8609A2 turns the charging control FET on and returns to the normal condition.
2. When a load is connected and dischar ging starts, the FH8609A2 turns the chargi ng control FET on and returns to the norma l condition. The release mechanism is as fo llows: the discharging current flows through an internal parasitic diode of the charging F ET immediately after a load is connected a nd discharging starts, and the VM pin volta ge increases about 0.7 V (forward voltage of the diode) from the GND pin voltage mo mentarily. The FH8609A2 detects this volta ge and releases the overcharge condition. Consequently, in the case that the battery

voltage is equal to or lower than the overcharge detection voltage (V_{CU}), the FH8609A2 returns to the normal condition immediately, but in the case the battery voltage is higher than the overcharge detection voltage (V_{CU}),the chip does not return to the normal condition until the battery voltage drops below the overcharge detection voltage (V_{CU}) even if the load is connected. In addition, if the VM pin voltage is equal to or lower than the overcurrent 1 detection voltage when a load is connected and discharging starts, the chip does not return to the normal condition.

Remark

If the battery is charged to a voltage higher than the overcharge detection voltage (V_{CU}) and the battery voltage does not drops below the overcharge detection voltage (V_{CU}) even when a heavy load, which causes an overcurrent, is connected, the overcurrent 1 and overcurrent 2 do not work until the battery voltage drops below the overcharge detection voltage (V_{CU}). Since an actual battery has, however, an internal impedance of several dozens of mΩ, and the battery voltage drops immediately after a heavy load which causes an overcurrent is connected, the overcurrent 1 and overcurrent 2 work. Detection of load short-circuiting works regardless of the battery voltage.

Overdischarge Condition

When the battery voltage drops below the overdischarge detection voltage (V_{DL}) during discharging under normal condition and it continues for the overdischarge detection delay time (t_{DL}) or longer, the FH8609A2 turns the discharging control FET off and stops discharging. This condition is called overdischarge condition. After the discharging control FET is turned off, the VM pin is pulled up by the R_{VMD} resistor between VM and VDD in FH8609A2. Meanwhile when VM is bigger than 1.5V (typ.) (the load short-circuiting detection voltage), the current of the chip is reduced to the power-down current (I_{PDN}). This condition is called power-down condition. The VM and VDD pins are shorted by the R_{VMD} resistor in the IC under the overdischarge and power-down conditions.

The power-down condition is released when a charger is connected and the potential difference between VM and VDD becomes 1.3 V (typ.) or higher (load short-circuiting detection voltage). At this time, the FET is still off. When the battery voltage becomes the overdischarge detection voltage(VDL) or higher (see note), the FH8609A2 turns the FET on and changes to the normal condition from the overdischarge condition.

Remark

If the VM pin voltage is no less than the charger detection voltage (V_{CHA}), when the battery under overdischarge condition is connected to a charger, the overdischarge condition is released (the discharging control FET is turned on) as usual, provided that the battery voltage reaches the overdischarge release voltage (V_{DU}) or higher.

Overcurrent Condition

When the discharging current becomes equal to or higher than a specified value (the VM pin voltage is equal to or higher than the overcurrent detection voltage) during discharging under normal condition and the state continues for the overcurrent detection delay time or longer, the FH8609A2 turns off the discharging control FET to stop discharging. This condition is called overcurrent condition. (The overcurrent includes overcurrent, or load short-circuiting.)

The VM and GND pins are shorted internally by the R_{VMS} resistor under the overcurrent condition. When a load is connected, the VM pin voltage equals the VDD voltage due to the load.

The overcurrent condition returns to the normal condition when the load is released and the impedance between the B+ and B- pins becomes higher than the automatic recoverable impedance. When the load is removed, the VM pin goes back to the GND potential since the VM pin is shorted the GND pin with the R_{VMS} resistor. Detecting that the VM pin potential is lower than the overcurrent detection voltage (V_{IOV}), the IC returns to the normal condition.

Abnormal Charge Current Detection

If the VM pin voltage drops below the charger detection voltage (V_{CHA}) during charging under the normal condition and it continues for the overcharge detection delay time (t_{CU}) or longer, the FH8609A2 turns the charging control FET off and stops charging. This action is called abnormal charge current detection.

Abnormal charge current detection works when the discharging control FET is on and the VM pin voltage drops below the charger detection voltage (V_{CHA}). When an abnormal charge current flows into a battery in the overdischarge condition, the FH8609A2 consequently turns the charging control FET off and stops charging after the battery voltage becomes the overdischarge detection voltage and the overcharge detection delay time (t_{CU}) elapses.

Abnormal charge current detection is released when the voltage difference between VM pin and GND pin becomes lower than the charger detection voltage (V_{CHA}) by separating the charger. Since the 0 V battery charging function has higher priority than the abnormal charge current detection function, abnormal charge current may not be detected by the product with the 0 V battery charging function while the battery voltage is low.

Load Short-circuiting condition

If voltage of VM pin is equal or below short circuiting protection voltage (V_{SHORT}), the FH8609A2 will stop discharging and battery is disconnected from load. The maximum d elay time to switch current off is t_{SHORT}. This status is released when voltage of VM pin i s higher than short protection voltage (V_{SHORT}), such as when disconnecting the load.

Delay Circuits

The detection delay time for overdischarge current 2 and load short-circuiting starts when overdischarge current 1 is detected. As soon as overdischarge current 2 or load short-circuiting is detected over detection delay time for overdischarge current 2 or load short-circuiting, the FH8609A2 stops discharging. When battery voltage falls below overdischarge detection voltage due to over discharge current, the FH8609A2 stop discharging by overdischarge current detection. In this case the recovery of battery voltage is so slow that if battery voltage after overdischarge voltage detection delay time is still lower than overdischarge detection voltage, the FH8609A2 shifts to power-down.

0V Battery Charging Function (1) (2) (3)

This function enables the charging of a connected battery whose voltage is 0V by self-discharge. When a charger having 0V battery start charging charger voltage (V_{0CHA}) or higher is connected between B+ and B- pins, the charging control FET gate is fixed to VDD potential. When the voltage between the gate and the source of the charging control FET becomes equal to or higher than the turn-on voltage by the charger voltage, the charging control FET is turned on to start charging. At this time, the discharging control FET is off and the charging current flows through the internal parasitic diode in the discharging control FET. If the battery voltage becomes equal to or higher than the overdischarge release voltage (V_{DU}), the normal condition returns.

Note:

(**1**) Some battery providers do not recommend charging of completely discharged batteries. Please refer to battery providers before the selection of 0 V battery charging function.

(**2**) The 0V battery charging function has higher priority than the abnormal charge current detection function. Consequently, a product with the 0 V battery charging function charges a battery and abnormal charge current cannot be detected during the battery voltage is low (at most 1.8 V or lower).

(**3**) When a battery is connected to the IC for the first time, the IC may not enter the normal condition in which discharging is possible. In this case, set the VM pin voltage equal to the GND voltage (short the VM and GND pins or connect a charger) to enter the normal condition.

TIMING CHART

1. Overcharge and Overdischarge voltage detection

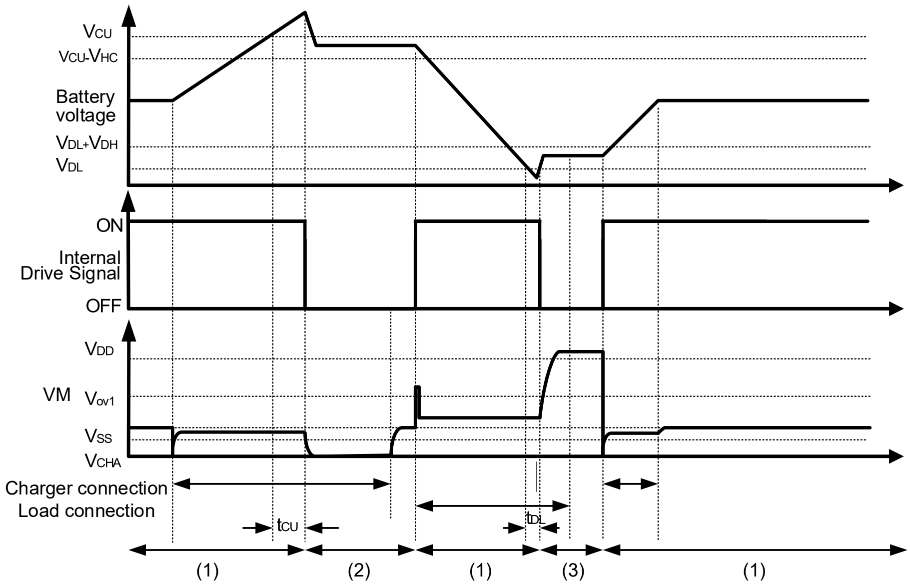


Figure4-1 Overcharge and Overdischarge Voltage Detection

Remark: (1) Normal condition (2) Overcharge voltage condition (3) Overdischarge voltage condition

2. Overdischarge Current and Load Short detection

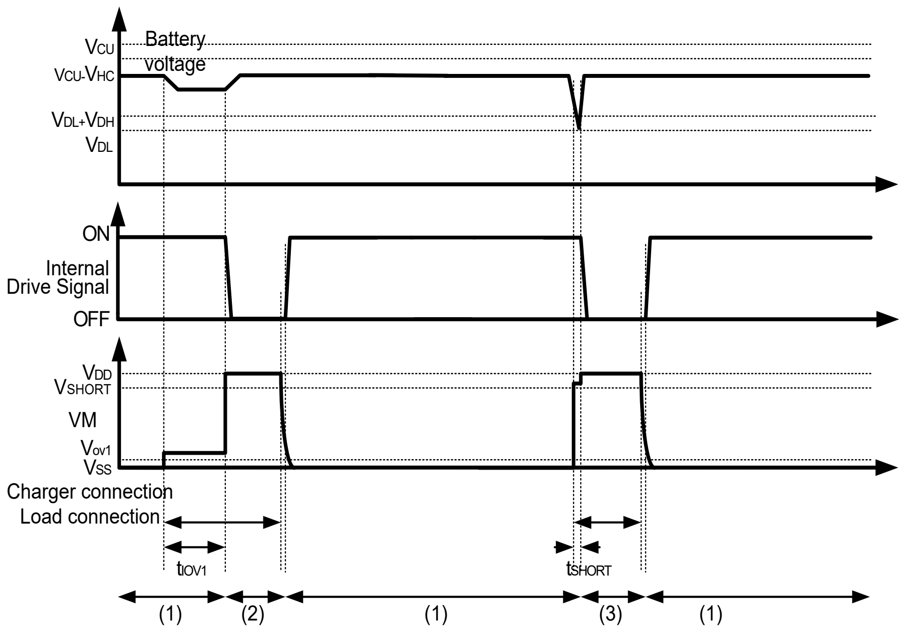


Figure4-2 Overdischarge Current and Short Detection

Remark: (1) Normal condition (2) Overcharge voltage condition (3) Overdischarge voltage condition

3. Abnormal Charger Detection

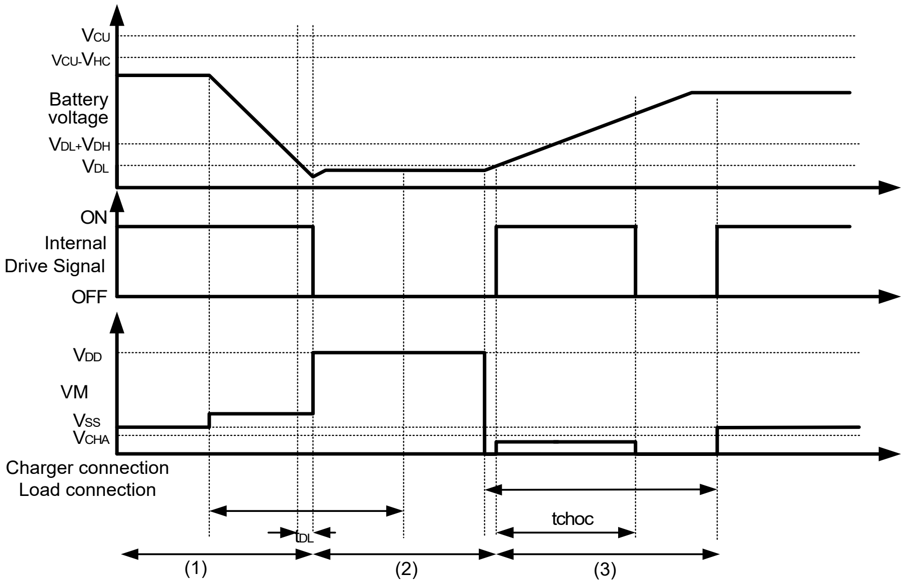


Figure4-3 Abnormal Charger Detection

Remark: (1) Normal condition (2) Overdischarge voltage condition (3) Overcharge voltage condition

TYPICAL APPLICATION

As shown in Figure 5, the current path and must be kept as short & heavy as possibl e. C1 is a filter decoupling circuit and should be as close as possible to VCC pin of FH8609A2.

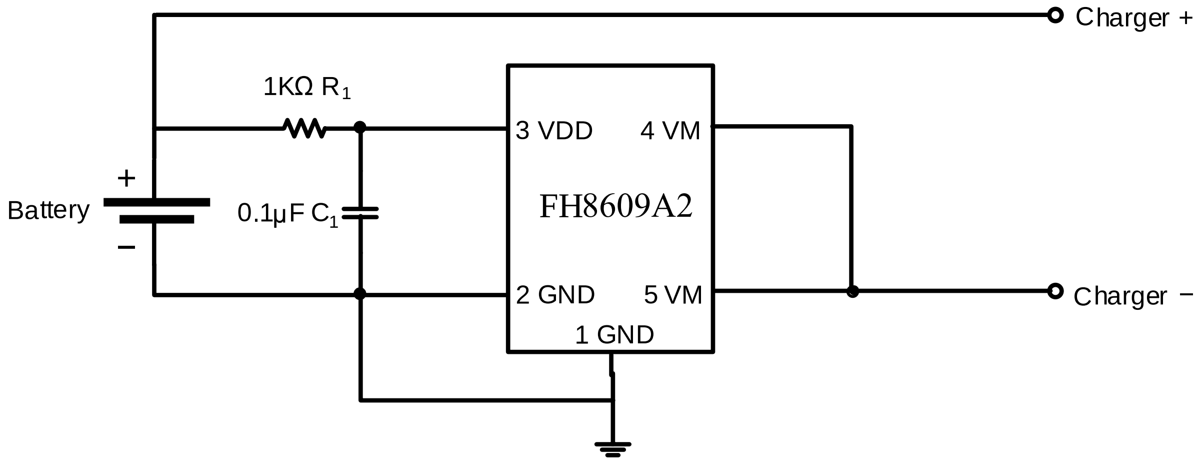


Figure 5 FH8609A2 in a Typical Battery Protection Circuit

Symbol	Typ	Value range	Unit
C1	0.1	0.1~2.2	μF
R1	1	0.47~2	KΩ

Remark:
1.The above parameters may be changed without notice;
2.The schematic diagram and parameters of the IC are not used as the basis to ensure the operation of the circuit. Please conduct full measurement on the actual application circuit before setting the parameters.

Precautions

- Pay attention to the operating conditions for input/output voltage and load current so that the power loss in FH8609A2 does not exceed the power dissipation of the package.
- Do not apply an electrostatic discharge to this FH8609A2 that exceeds the performance ratings of the built-in electrostatic protection circuit.

APPLIED MEASUREMENT METHOD

(1).Overcharge characteristic test method:

a. According to the figure6-1, connect the power supply DC1 to the B + and GND pins of the system board and set the voltage to about 3.6V. Connect the power supply from GND to VM to DC2 power supply and set 100mV current limiting 10mA. Observe the waveform.

b. Adjust the power supply voltage V1 and increase it by 0.001V until the output level of VM pin changes from 0 to negative (-100mV). Record the overcharge protection voltage and measure the protection delay.

c. Adjust the power supply voltage V1 to decrease by 0.001V until the output voltage of VM pin is recovered from negative (-100mV) to 0 level, and record the overcharge recovery voltage.

(2).Over discharge characteristic test method:

a. According to the figure6-2, connect the power supply DC1 to the B + and GND pins of the system board and set the voltage to about 3.6V. Connect the DC2 power supply from VM to GND, set the 100mV current limiting 10mA, and observe the waveform.

b. Adjust the power supply voltage V1 and increase it by 0.001V until the output level of VM pin changes from 0 to positive (100mV). Record the overcharge protection voltage and measure the protection delay.

c. Adjust the power supply voltage V1 to decrease by 0.001 V until the output voltage of VM pin is restored from positive (100 mV) to 0 level, and record the overcharge recovery voltage.

(3).Discharge over current test method:

a. According to the figure6-3, connect the DC1 power supply to the B + and GND pins of the system board and set the voltage to about 3.0V/3.6V/4.2V. Connect the electronic load from B + to VM and observe the waveform.

b. Adjust the electronic load increase it by 0.1A step, detect that the current from B + to VM is turned off and meet the delay standard (about 10ms), and record the discharge delay time.

(4).Charging over current test method:

a. According to the figure6-4, connect the DC1 power supply to the B + and GND pins of the system board and set the voltage to about 3.0V/3.6V/4.2V, and load DC2 power supply from GND to VM.

b. Adjust the current limiting value of DC2 power supply to increase by 0.1A step, detect that the current from GND to VM is turned off and meet the delay standard(about 10ms), and record the charging over-current delay time.

(5).Iq test method:

a. As shown in the figure6-5, connect the positive pole of DC1 to B +, and the negative pole to GND, and set the voltage to 3.6V;

b. VM grounding, record the current passing through DC1 (Iq).

(6).Isd test method:

a. As shown in the figure6-6, connect the positive pole of DC1 to B + and the negative pole to GND, and set the voltage to 2V;

b. VM is suspended and the current passing through DC1 is recorded as Isd.

SCHEMATIC DIAGRAM OF TEST METHOD

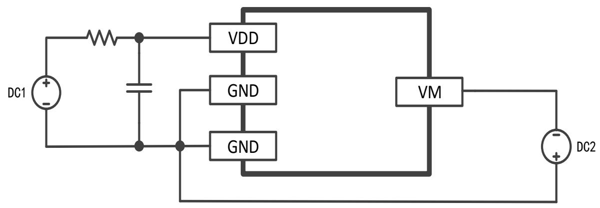


Figure6-1

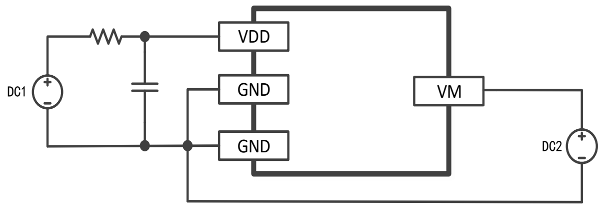


Figure6-2

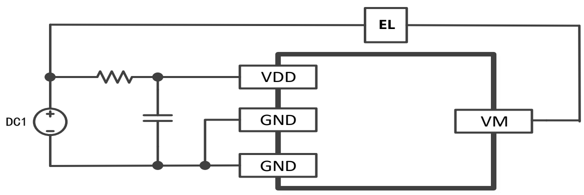


Figure6-3

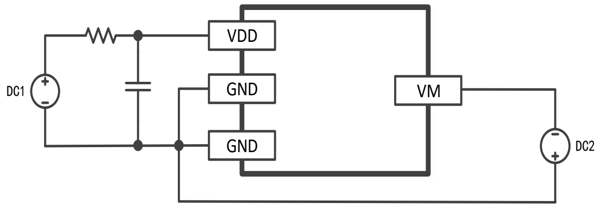


Figure6-4

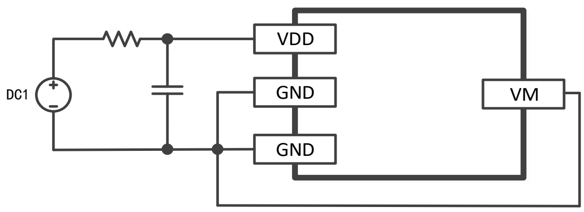


Figure6-5

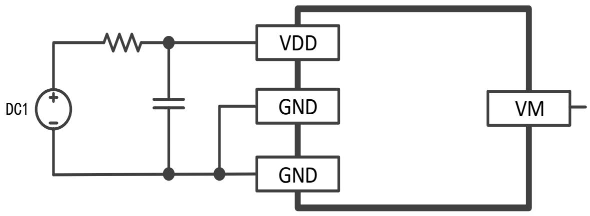
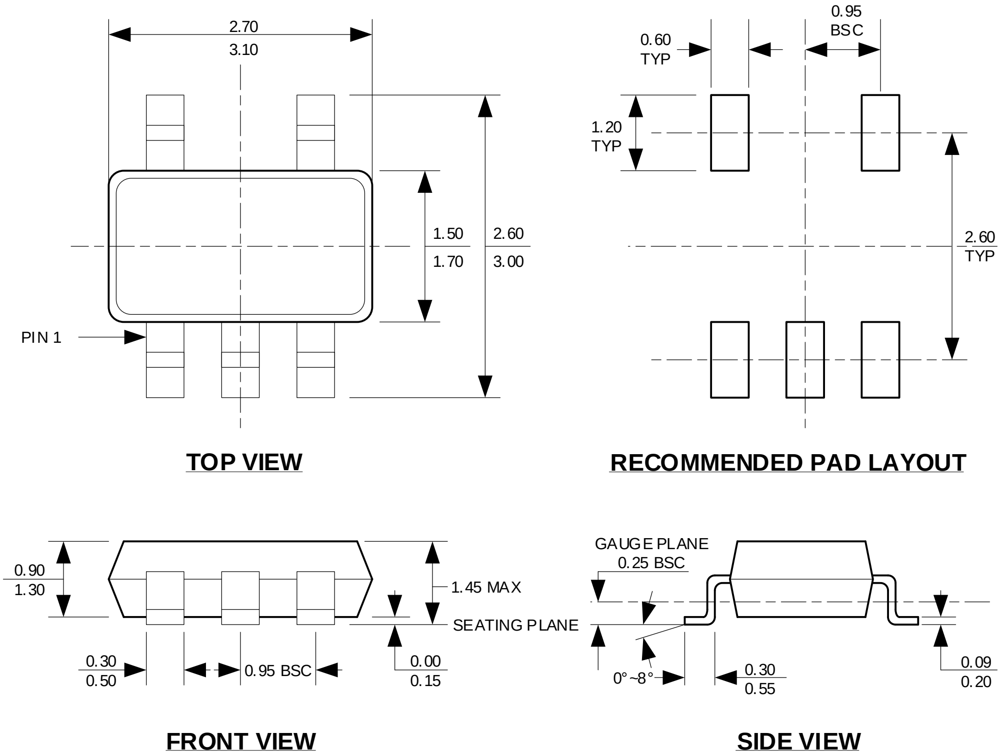


Figure6-6

Package Information: SOT23-5

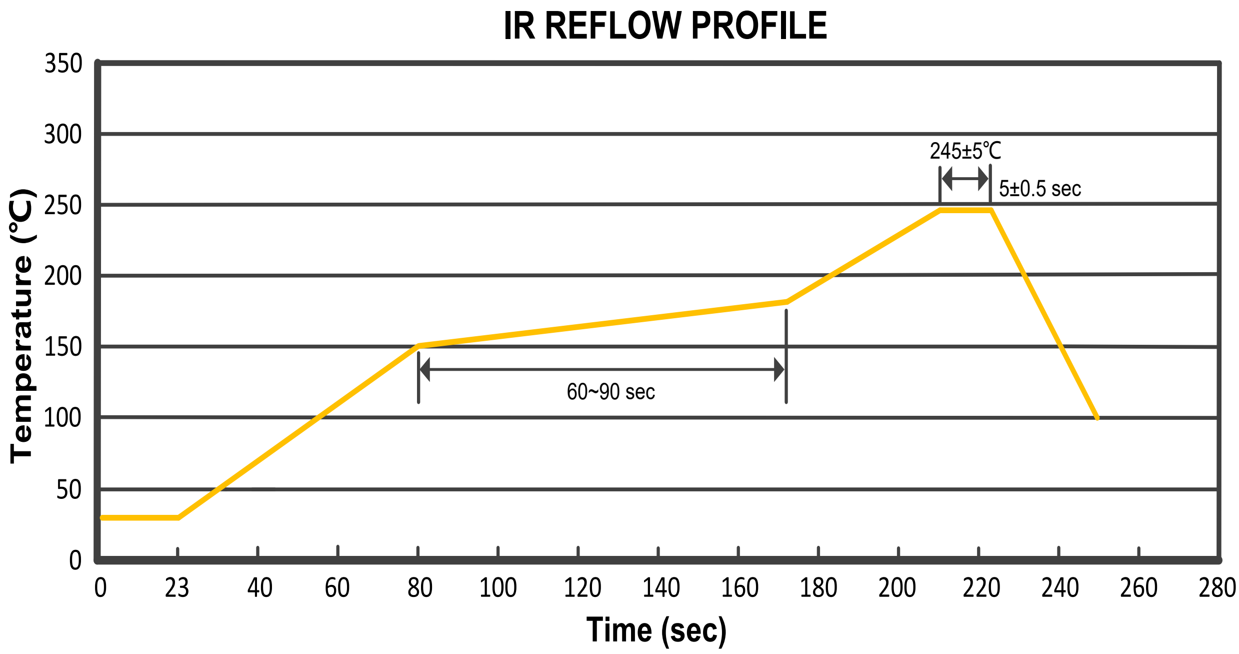


NOTE:
1. CONTROL DIMENSION IS IN INCHES. DIMENSION IN BRACKET IS IN MILLIMETERS.
2. PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
3. PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
4. LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.004" INCHES MAX.
5. DRAWING CONFORMS TO JEDEC MS-012, VARIATION BA.
6. DRAWING IS NOT TO SCALE.

NOTICE:

1. The information here contained could be changed without notice owing to product and/or technical improvements. Please make sure before using the product that the information you are referring to is up to date.
2. No responsibilities are assumed by us for any consequence resulting from any wrong or improper operation, etc. of the product

Solderability Curve of Lead-Free Reflow Soldering (applicable to SMT tube)



Explain:
1.Preheating temperature 25~150℃, duration 60~90sec;
2.Peak temperature 245 ± 5 ℃, duration 5 ± 0.5sec;
3.Cooling rate of welding process is 2~10℃/sec.

Resistance to welding heat conditions

Temperature: 270±5℃; Time:10±1sec