Programmable voltage and current linear battery management chip

■ General Description

The HM4059 is charging management circuit that can be programmed through an external resistor constant current / constant voltage charging. The device includes an internal power transistor, does not need external current sense resistor and blocking diode in applications. HM4059 requires minimal external components, and meet the USB bus specification, is very suitable for portable applications in the field.

Thermal modulation circuit can control the internal chip temperature in a safe range when the device power dissipation be relatively large or the ambient temperature be higher. The output voltage can be programmed by an external resistor. Charging current is set by an external resistor. When the input voltage (AC adapter or USB power supply) power is lost, HM4059 automatically enters a low power sleep mode, then the battery current consumption is less than 0.1µA. Built-in protection circuits against irrigation, when the battery voltage is higher than the input voltage, automatically turn off built-in power MOSFET. Other features include low input voltage latch, automatic recharge, the battery temperature monitoring, Built - in OVP protection and charge status / charge status indication functions.

The internal use of the patented technology is to realize protecting reverse battery. When the battery is reversed, stop charging, indicator

The HM4059 adopted the thermally enhanced eSOP-8.

■ Features

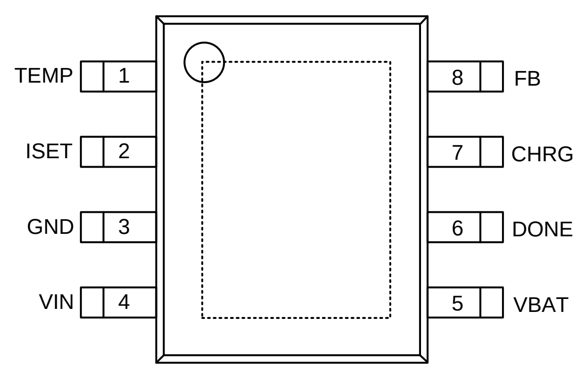
- In the package allows the range of programmable charge current up to 1.2A above
- No MOSFET, sense resistor or blocking diode required
- Complete linear charger in small package for single cell lithium-ion batteries
- Constant-current/constant-voltage operation with thermal regulation to maximize charge rate without risk of overheating
- Charging voltage can be adjusted by the FB
- Monitor output charge current
- Charging status indicator and full status flag
- 3/10 charge current termination
- Automatic recharge
- 40µA supply current in shutdown
- 0.7 times the programming voltage trickle charge threshold voltage
- Soft-Start limits inrush current
- OVP protection function , the input is higher than8.0V, stop charging
- Output with protection against anti-irrigation
- Available in eSOP-8/PP or eMSOP-8/PP Package
- When you unplug VIN , the IC does not consume battery power

■ Applications

- Mobile phones
- Digital Cameras
- MP4 Player
- Bluetooth applications
- Electronic Dictionary
- portable devices
- all kinds of charger
- Mobile power

■ Package

- eSOP-8/PP



eSOP-8
(Top View)

■ Ordering Information

HM4059①②③④⑤

Designator	Description	Symbol	Description
①	FB Voltage Range	A	1.212-1.225
		B	1.225-1.238
②	Packaging Types	S	eSOP-8
③	Device Orientation	R	positive
		L	negative

■ Pin Function

- **TEMP (Pin 1):** The TEMP pin to the battery of the NTC sensor output. If the TEMP pin voltage is less than the input voltage of 30% or greater than 60% of the input voltage means the battery temperature is too low or too high, then the charge will be suspended. If the TEMP input voltage between 30% and 60%, then the battery fault condition will be cleared, the charge will continue. If you want to shield this feature ,you can connecte the PIN to GND.

- **ISET (Pin 2):** Charge current programming, charge current monitoring and close pin. Charge current is controlled by a resistor of precision of 1%to the ground. In the constant charge current state, this port provides 1V voltage. In all conditions, this port charge current can be calculated using the following formula:

  $$I_{BAT} = (V_{ISET}/R_{ISET}) \times 1000$$

  ISET port can also be used to turn off the charger. Resistance to side with the separation of programming can pull the 3μA current source to increase ISET port voltage. When the suspension reached the limit voltage 1.21V, the device enters stop state, after charging the input current drop to 25μA. This port pinch-off voltage is about 2.4V. If supply this port voltage more than pinch-off voltage, the current will be 1.5 mA. Through combinating ISET pin to the ground, the charger will back to normal.

- **GND (Pin 3):** Ground terminal .The EXPOSED pin is also connected with pin 3.

- **VIN (Pin 4):** Supply positive input voltage. Power supply for the charger. VCC can be 4.25V to 8.0V and must have at least 1F bypass capacitor. If the BAT pin voltage of VCC down to within 30 mV, HM4059 into the suspension state, and make BAT Current less than 2A.

- **BAT (Pin 5):** Make the battery's positive terminal connected to this pin. When the power supply voltage lower than the threshold latch voltage or sleep mode voltage, BAT pin current is less than 2μA. BAT pin provide the battery charge current and constant voltage charging voltage.

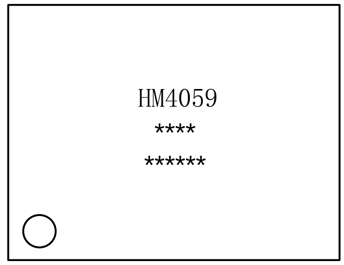
- **DONE (Pin 6):** When charging end, DONE pin is pulled high by internal switch represents that charge has ended; otherwise DONE pin is high impedance state.

- **CHRG (Pin 7):** When the charger to the battery charging, CHRG pin is pulled high by the internal switch,represents charging being; otherwise CHRG pin is in high impedance state.

- **FB (Pin 8):** This pin can test Kelvin battery voltage, and thus precisely modulated constant voltage battery charging voltage, avoiding the positive from the battery to the BAT pin HM4059 or contact resistance between the resistance wire and other parasitic resistance of the charge. If the FB pin and the BAT pin is an indirect one resistor, users can adjust the constant charging voltage.

Marking Rule

- **eSOP-8**



****** **Arinternal quality code!**

Absolute Maximum Ratings

<table>
<tr><th>Parameter</th><th>Symbol</th><th>Maximum Rating</th><th>Unit</th></tr>
<tr><td>Input Supply Voltage</td><td>V_{cc}</td><td>V_{SS}-0.3～V_{SS}+8.5</td><td rowspan="5">V</td></tr>
<tr><td>ISET pin Voltage</td><td>Vprog</td><td>V_{SS}-0.3～V_{cc}+0.3</td></tr>
<tr><td>BAT pin Voltage</td><td>Vbat</td><td>Vss-0.3～6</td></tr>
<tr><td>DONE pin Voltage</td><td>Vdone</td><td>V_{SS}-0.3～V_{SS}+7</td></tr>
<tr><td>CHAG pin Voltage</td><td>Vchrg</td><td>V_{SS}-0.3～V_{SS}+7</td></tr>
<tr><td>BAT pin Current</td><td>Ibat</td><td>1500</td><td>mA</td></tr>
<tr><td>ISET pin Current</td><td>Iprog</td><td>1500</td><td>µA</td></tr>
<tr><td>Operating Ambient Temperature</td><td>Topa</td><td>-40～+85</td><td rowspan="2">°C</td></tr>
<tr><td>Storage Temperature</td><td>Tstr</td><td>-65～+125</td></tr>
</table>

Caution: The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.

■ Typical Application Circuit

- **Constant- Current / Constant- Voltage 4.2V Charging Application**

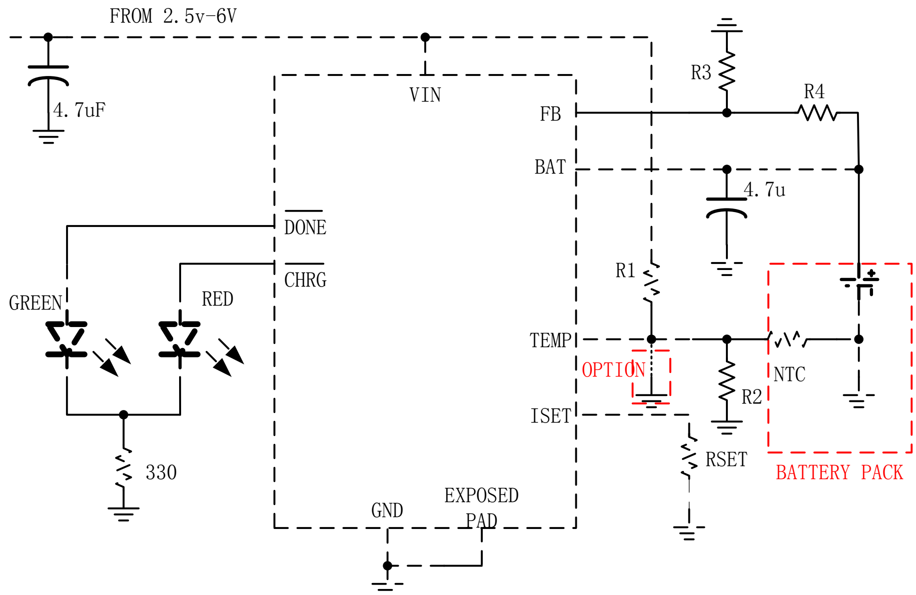


Figure 1

■ Block Diagram

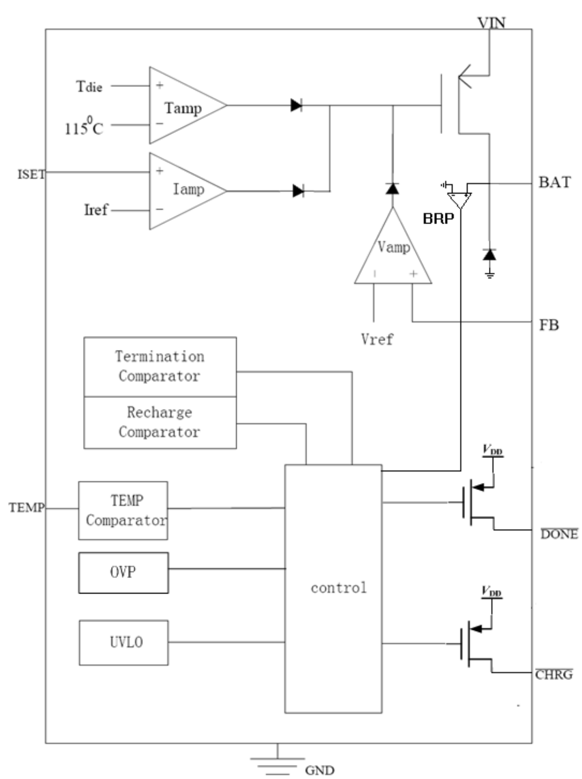


Figure 2

Electrical Characteristics

(Ta=25℃, 4.2V Lithium battery ,Unless specifically designated)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input supply voltage	Vcc		2.3		8.5	V
Input supply current	Icc	Charge mode,Riset=10K		200	2000	μA
		Standby mode		200	500	μA
		Shutdown mode(Riset not connected,Vcc<Vbat or Vcc<Vuv)		25	70	μA
Feedback Voltage	VFB	0℃≤TA≤85℃,IBAT=40mA	1.212	1.225	1.238	V
BAT pin Current	Ibat	Riset=10k,Current mode	90	100	110	mA
		Riset=1k,Current mode	900	1000	1100	mA
		Standby mode,Vbat=4.2V	0	-2.5	-6	μA
		Shutdown mode			±0.1	μA
		Sleep mode,Vcc=0V			±0.1	μA
Trickle charge current	Itrikl	Vbat<Vtrikl,Rprog=2k	90	100	110	mA
Trickle charge Threshold Voltage	Vtrikl	Riset=10K，Vbat Rising	2.8	2.9	3.0	V
Trickle voltage hysteresis voltage	Vtrhys	Riset=10k	60	80	110	mV
Vcc Undervoltage lockout Threshold	Vuv	From Vcc low to high	3.7	3.8	3.93	V
Vcc undervoltage lockout hysteresis	Vuvhys		150	200	300	mV
Manual shutdown threshold voltage	Vmsd	Iset pin rising	1.15	1.21	1.30	V
		Iset pin falling	0.9	1.0	1.1	V
Vcc-Vbat Lockout Threshold voltage	Vasd	Vcc from low to high	70	100	140	mV
		Vcc from high to low	5	30	50	mV
3C/10 Termination Current Threshold	Iterm	Riset=10k	20	30	40	mA
		Riset=2k	120	150	190	mA
PROG pin Voltage	Vprog	Riset=10k, Current mode	0.93	1.0	1.07	V
Battery reversed current	I_{FBAT}	VDD=5V,VBAT=-4.2V	-0.5	-0.7	-1	mA
CHRG pin Output low voltage	Vdone	Idone=5mA	V_{CC}-0.3		V_{CC}+0.3	V
CHRG pin Output low voltage	Vchrg	Ichrg=5mA	V_{CC}-0.3		V_{CC}+0.3	V
Recharge Battery threshold Voltage	Δ Vrecg	VFLOAT - VRECHRG		80	120	mV

■ Application Information

- **set constant voltage charging voltage**

Through an external resistor, the output voltage can be set , taking into account the accuracy requirements , it is recommended that the resistor with an accuracy of 1% . Constant voltage charging voltage (VBAT) can be calculated:

$$VBAT=VFB\times(1+R4 / R3)$$

- **Set the charge current**

In constant-current mode, formula for calculating charge current: ICH = 1000V / RISET

ICH represents the charge current, units is ampere, RISET represents ISET pin to ground resistance in ohms.For example, if you need 500 mA charge current, according to the following formula: RISET = 1000V/0.5A = 2KΩ

In order to ensure good stability and temperature characteristics, RISET recommend the use of 1% precision metal film resistors. By measuring the ISET pin voltage can be detected charge current. Charge current can be calculated using the following formula: ICH = (VISET / RISET) × 1000

- **Battery temperature monitoring**

In order to prevent the battery temperature is too high or too low on the battery damage, HM4059 internal battery temperature monitoring of integrated circuits. Battery temperature monitoring is by measuring the TEMP pin voltage to achieve, TEMP pin voltage is within the battery NTC thermistor and a resistor divider network.

HM4059 the TEMP pin voltage with the chip and the two thresholds VLOW VHIGH compared to confirm whether the battery temperature exceeds the normal range. In the HM4059, VLOW were fixed in 30% × VIN, VHIGH were fixed in 60% × VIN. If the TEMP pin voltage VTEMP <VLOW or VTEMP> VHIGH, the battery temperature is too high or too low, charging will be suspended; If the TEMP pin voltage VTEMP VLOW and VHIGH in between, the charge cycle will continue.

- **Enable design**

By controlling whether the ISET pin resistor connected, users can reach close HM4059 function. Figure 3a .

Can also be achieved simultaneously through the TEMP port Close HM4059 the function. When the external battery is not in NTC resistor can be set through the microcontroller TEMP port Wade is 0 to achieve open HM4059, to configure external resistors R1 and R2 to achieve closure HM4059 Figure 3b.

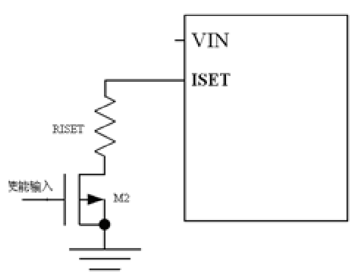


图3a

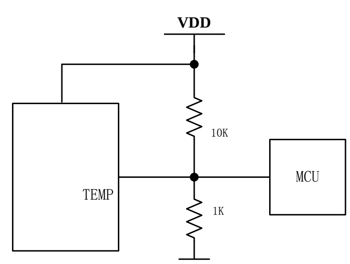


图3b

Figure 3. HM4059 Enable Design

- **Determine the value of R1, R2**

The value of R1 and R2 according to battery temperature monitoring range and the thermistor resistance values to determine, are described as follows: assume that the temperature range of the battery set TL ~ TH, (TL <TH); batteries

used in negative temperature coefficient thermistor (NTC), RTL TL when its temperature resistance, RTH its resistance when the temperature TH, then the RTL> RTH, then the temperature TL, the first pin TEMP-side voltage is:

$$V_{TEMPL} = \frac{R_2 // R_{TL}}{R_1 + R_2 // R_{TL}} \times Vin$$

When the temperature reaches TH, the first side of the TEMP pin voltage is: $V_{TEMPH} = \frac{R_2 // R_{TH}}{R_1 + R_2 // R_{TH}} \times Vin$

then，according to: $V_{TEMPL} = V_{HIGH} = K2 \times V_{IN} (K2 = 0.6)$

$$V_{TEMPH} = V_{LOW} = K1 \times V_{IN} (K1 = 0.3)$$

Can solve for: $R1 = \frac{R_{TL} R_{TH} (K2 - K1)}{(R_{TL} - R_{TH}) K1K2}$

$$R2 = \frac{R_{TL} R_{TH} (K2 - K1)}{R_{TL}(K1 - K1K2) - R_{TH}(K2 - K1K2)}$$

Similarly, if the battery is the positive temperature coefficient of internal (PTC) thermistor the RTH> RTL, we can calculate:

$$R1 = \frac{R_{TL} R_{TH} (K2 - K1)}{(R_{TH} - R_{TL}) K1K2}$$

$$R2 = \frac{R_{TL} R_{TH} (K2 - K1)}{R_{TH}(K1 - K1K2) - R_{TL}(K2 - K1K2)}$$

从 From the above derivation can be seen to be setting the temperature range and supply voltage VIN is irrelevant, only with R1, R2, RTH, RTL; one, RTH, RTL can access the relevant manuals or through experimental test battery be.

In practice, if only one side of the temperature characteristics of concern, such as over-temperature protection, then R2 can't and can only R1. R1 derivation becomes very simple, not discussed here

- **Open-drain output status indication**

HM4059 has two open-drain status indication sides, CHAG and DONE, the two status indicator LEDs client can drive or microcontroller port. CHAG used to indicate charging status, charging time, CHAG is high; DONE to indicate the charging end of the state, when the charging end, DONE is high. When the battery temperature is outside the normal temperature range more than 0.15 seconds, CHAG and the DONE pin is high impedance output state.

When the battery charger not received, the charger will quickly charge the output capacitor to the constant voltage value, as the battery voltage detection the BAT pin input leakage current, the BAT pin voltage will slowly down to recharge threshold, so the BAT pin voltage is 150mv to form a ripple waveform, while CHAG output pulse signal that there is no battery installed. When the battery BAT pin external connectors for the 4.7uF capacitor, the pulse period of about 2Hz

The following table lists CHAG and DONE pin status in each case:

State	Charge	Full	Without Battery	Error
CHRG	Always bright	Always off	Flashing	Always off
DONE	Always off	Always bright	Always bright	Always off

Note: 1. CHAG flicker frequency with external capacitor when not connect battery, generally recommended 4.7uF.The greater the capacitance, the smaller frequency flicker.

2. The error situation: Beyond the operating temperature range (temperature too high or too low), I set side vacant, Vin <Vbat, Vin <3.8V and so on.

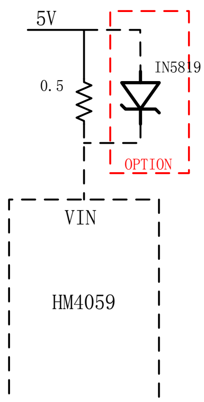
- **The large current output design**

Since the HM4059 using the internal constant power technology, therefore , when the input VIN and BAT pressure is too large , will lead to smaller the BAT voltage range of the maximum current , so that the charging time becomes longer , in order to make the maximum current charging interval larger by an external resistor or Schottky methods to achieve.

The assumption the HM4059 of SOP8/PP inside the package the maximum allowable power 1.2W, maximum charge current is set to 1.2A . If uses a resistive, We assume that the use of the resistance of 0.5Ω (1W), High current charging, the voltage drop across the resistor is 0.5*1.2=0.6V. The HM4059 real operating voltage is 4.4V. Thus, in this state, (VIN-VBAT) *1.2<1.2W, therefore VBAT>3.6V， The battery voltage is above 3.6V 1.2A charging support.Below 3.6V, the HM4059 will automatically reduce the charge current to maintain the chip internal power balance.

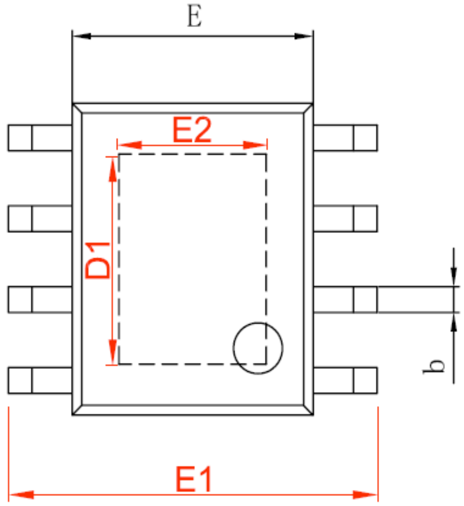
If Schottky similar calculation can be made , according to the Schottky voltage drop at different current .

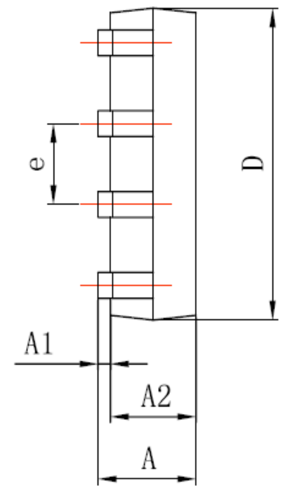
n addition , in the high-current applications need to pay attention HM4059 PCB layout design must consider increasing EXPOSED PAD area , and will be connected to the EXPOSED PAD to GND in order to improve the thermal performance , and ensure the stable operation of the chip .

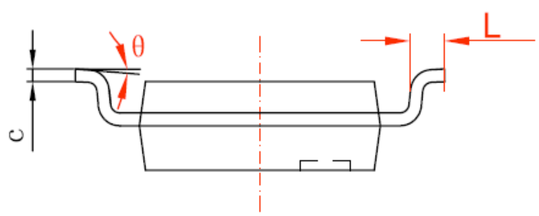


■ Package Information

- **eSOP-8/PP**







Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.150	0.002	0.006
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.200
D1	3.202	3.402	0.126	0.134
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
E2	2.313	2.513	0.091	0.099
e	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°