

## 2.0A, 1 / 2 节锂电池开关型充电器

### 产品概述

HM4090 是一款 5V-24V 输入,高度集成的开关型锂离子/聚合物电池充电芯片,以高精度调节 2A 充电电流,和电池电压。它密切监测电池组的温度只在设置安全温度范围下允许充电,还提供电池检测、预充电调节、充电饱和和充电状态指示等功能。热反馈调节可降低充电电流并维持芯片内部温度以不超过 125°C 的条件下工作,如果结温超过 155°C,它将进行过热关断保护,停止工作以确保可靠度。

HM4090 适合单/两节电池充电,它集成 24V 耐压,低导通组抗的 N-型场效应晶体管以 1.0MHZ 同步降压管理实现高效率的锂电池充电并简化外围电路设计。HM4090 封装为 SOP8-e。

### 产品特点

- 1MHz 同步降压调节
- MOS 集成
- 可编程(Max.2A)恒流充电
- 1 / 2-节电池供电
- 5~24V 工作电压范围
- 高达 93%的效率
- 内部软启动
- 内部环路补偿
- 多重保护
  - 输出短路保护
  - 过温度保护
  - 电池过电压保护 (BOVP)
  - 充电定时器
  - 热反馈调节@T<sub>j</sub>=125C
  - NTC 检测, 温度异常充电暂停
- 充电状态指示
- 精确度
  - ±1% 电池电压调节(CV)
  - ±10% 充电电流调节(CC)

### 应用领域

- 平板电脑
- 电动工具
- 蓝牙音箱
- POS 机
- 无线对讲机

## Typical Application Circuits

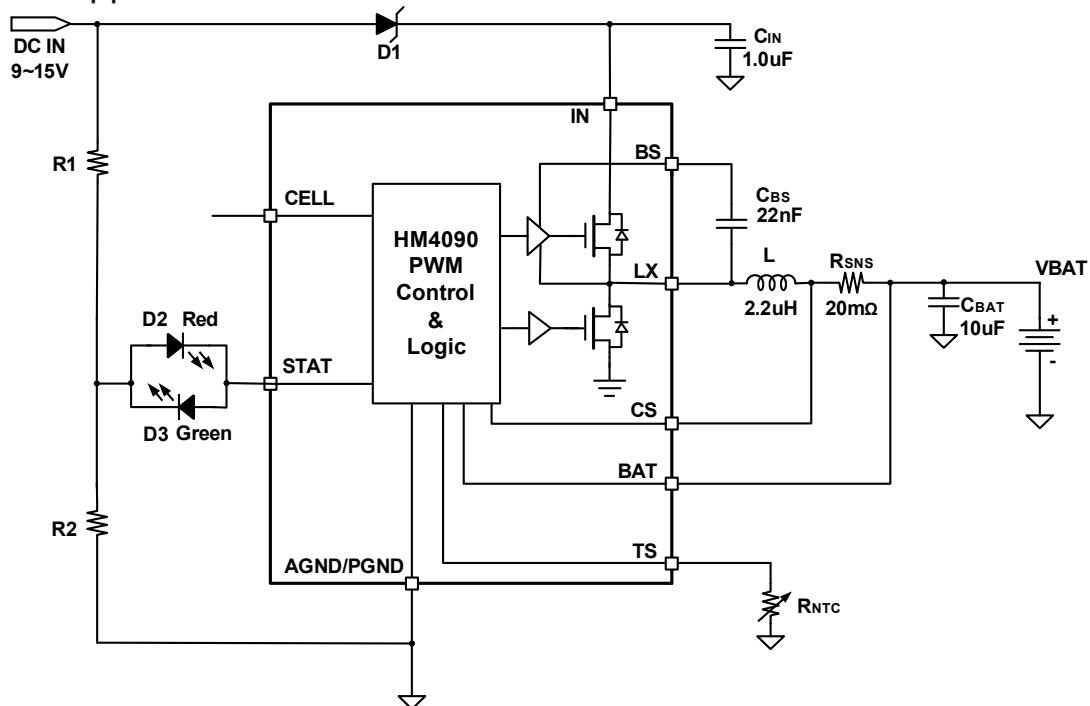


Figure 1. Typical Application Schematic for 2-Cells Battery (Block reverse current with a Schottky diode)

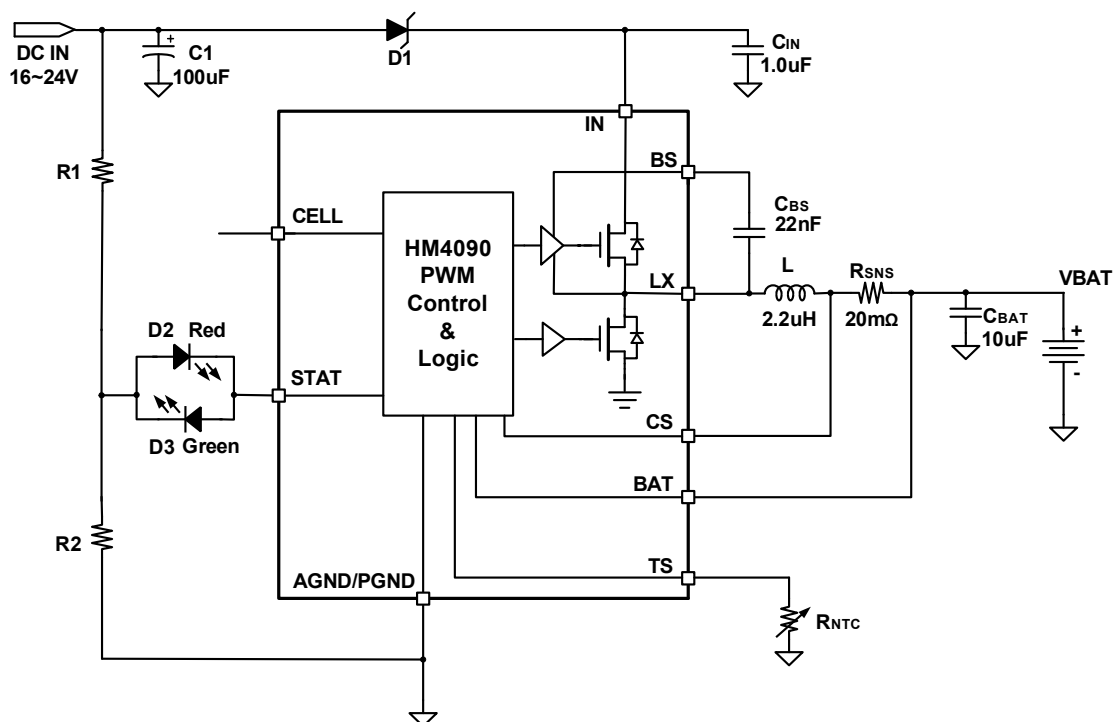


Figure 2. Typical Application Schematic for 2-Cells Battery if Input Power Exceeded 15V  
(add C1=100uF electrolytic capacitor for surge protection)

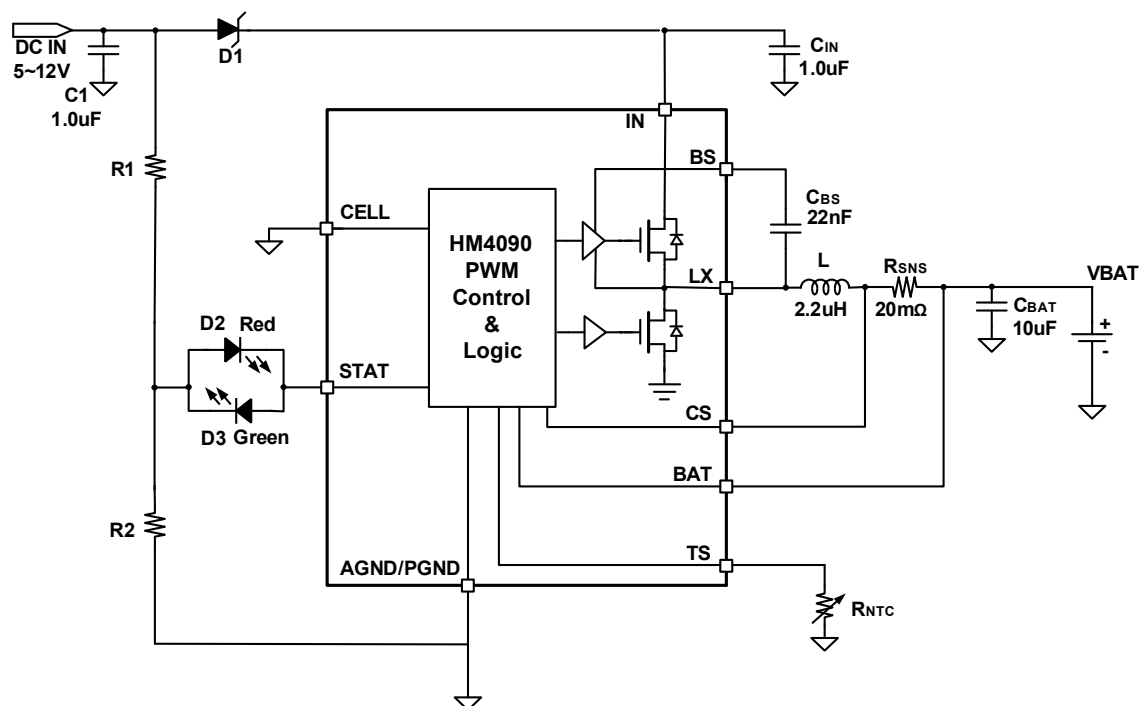


Figure 3. Typical Application Schematic for 1-Cells Battery

## PIN Configuration

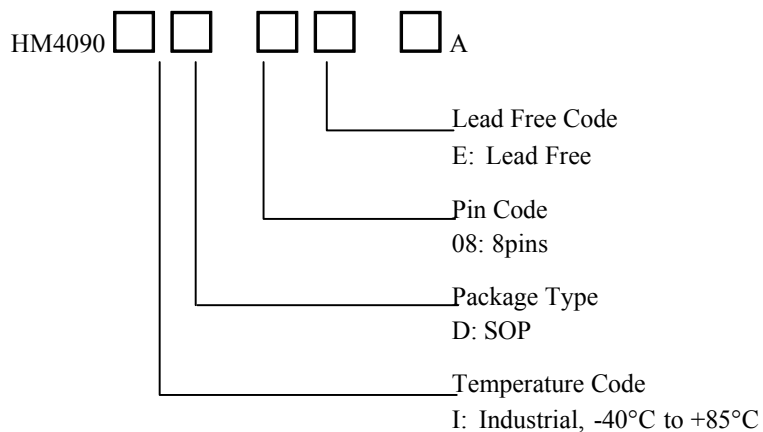
| Package | PIN-OUT                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SOP8-e  | <p>Diagram illustrating the PIN-OUT configuration for the HM4091 device in the SOP8-e package. The pins are numbered 1 through 8, and the internal connections are labeled as follows:</p> <ul style="list-style-type: none"> <li>Pin 1: BS</li> <li>Pin 2: STAT</li> <li>Pin 3: TS</li> <li>Pin 4: CELL</li> <li>Pin 5: BAT</li> <li>Pin 6: CS</li> <li>Pin 7: LX</li> <li>Pin 8: IN</li> <li>Internal Block: AGND/PGND</li> </ul> |

## PIN Description

| PIN NO. | Name          | Description                                                                                                          |
|---------|---------------|----------------------------------------------------------------------------------------------------------------------|
| 1       | BS            | Bootstrap 引脚。<br>在 LX 和 BS 之间使用 10~22nF 的瓷片电容连接。                                                                     |
| 2       | STAT          | 状态输出                                                                                                                 |
|         |               | Hi-Z      High      Low      Blinking                                                                                |
|         |               | 休眠模式      充电完成      充电中      异常                                                                                      |
| 3       | TS            | 电池温度采样端口，连接到电池温度调节器端子(NTC)，如果不连接到电池，可以连接至地以屏蔽NTC功能。推荐选料10K NTC (B-Constant=3950K)。<br><br>**TS引脚对地建议使用0.1uF瓷片电容，避免干扰 |
| 4       | CELL          | 充电节数选择引脚。<br>浮空为预设 2 节电池充电；下拉做 1 节充电；不可上拉；                                                                           |
| 5       | BAT           | 电池电压检测、充电电压调节和电流检测输入。BAT 与 AGND 使用 0.1uF 电容做共模滤波。<br>** PCB 电池接点 B+对地建议使用 1.0uF 并联 10uF 瓷片电容                         |
| 6       | CS            | 电流检测输入引脚。CS 与 AGND 建议接 0.1uF 做共模滤波。                                                                                  |
| 7       | LX            | 开关电流输出引脚，连接电感。<br>使用 10-22nF BS 电容跨接于 LX 与 BS 引脚之间用于上管驱动线路供电。                                                        |
| 8       | IN            | 芯片电源。使用 1uF 瓷片电容连接 AGND。<br>**输入电压超过 15V 以上时，建议于电源接点处使用 100uF 电解电容做为浪涌电压的吸收与保护。                                      |
| 9       | PGND/<br>AGND | 底部焊盘。连接到 PCB 的地。                                                                                                     |

## Order Information

| Order Number | Package Type | QTY/Reel | Green Status | Operation temp range |
|--------------|--------------|----------|--------------|----------------------|
| HM4090       | SOP8-e       | 2500     | RoHS         | -40 °C to 85°C       |



## Absolute Maximum Ratings

| Parameters                 | Maximum Ratings |
|----------------------------|-----------------|
| IN, CS, BAT, STAT          | -0.3V to 24V    |
| BS                         | -0.3V to 28V    |
| LX                         | -2V to 24 V     |
| TS                         | -0.3V to 7V     |
| PGND                       | -0.3V to +0.3V  |
| CS-BAT                     | -0.5V to +0.5V  |
| Junction temperature range | -40°C to +150°C |
| Storage temperature range  | -65°C to +150°C |
| Lead Temperature           | 260°C           |
| Maximum Power Dissipation  | 2W              |
| ESD (HBM)                  | 2000V           |

## Electrical Characteristics

| Symbol                    | Parameter                                                          | Condition                                                                                                          | SPEC |      |      | Unit |
|---------------------------|--------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|------|------|------|------|
|                           |                                                                    |                                                                                                                    | Min. | Typ. | Max. |      |
| Operating Conditions      |                                                                    |                                                                                                                    |      |      |      |      |
| V <sub>IN_OP</sub>        | IN input voltage operation range during charging                   |                                                                                                                    | 4.5  |      | 24   | V    |
| Quiescent Current         |                                                                    |                                                                                                                    |      |      |      |      |
| I <sub>BAT</sub>          | Battery discharge current (sum of currents into IN, CS, BAT)       | V <sub>IN</sub> < V <sub>UVLO</sub> , V <sub>BAT</sub> > V <sub>IN</sub> , T <sub>J</sub> =0°C to 85°C, Sleep Mode |      | 20   | 50   | uA   |
|                           |                                                                    | V <sub>IN</sub> > V <sub>UVLO</sub> , V <sub>IN</sub> > V <sub>BAT</sub> , Charge Done                             |      | 10   | 30   | uA   |
| I <sub>AC</sub>           | Adapter supply current (current into IN)                           | V <sub>IN</sub> > V <sub>UVLO</sub> , V <sub>IN</sub> > V <sub>BAT</sub> , Charge disabled                         |      | 2    | 3    | mA   |
|                           |                                                                    | V <sub>IN</sub> > V <sub>UVLO</sub> , V <sub>IN</sub> > V <sub>BAT</sub> , Charge enabled, switching               |      | 10   |      | mA   |
| Charge Voltage Regulation |                                                                    |                                                                                                                    |      |      |      |      |
| V <sub>BAT_REG</sub>      | BAT regulation voltage                                             | 1 cell, measured on BAT                                                                                            | 4.15 | 4.2  | 4.22 | V    |
|                           |                                                                    | 2 cells, measured on BAT                                                                                           | 8.30 | 8.35 | 8.41 | V    |
|                           | Charge voltage regulation accuracy                                 | T <sub>J</sub> =-20°C to 125°C                                                                                     | -1   |      | 1    | %    |
| Charge Current Regulation |                                                                    |                                                                                                                    |      |      |      |      |
| V <sub>CS-BAT_PC</sub>    | Charge Current Full Scale Sense Voltage in Pre-Charge              | R <sub>SNS</sub> =20mΩ                                                                                             | 1.5  | 3    | 4.5  | mV   |
| V <sub>CS-BAT_CC</sub>    | Charge Current Full Scale Sense Voltage in Constant Current Charge | R <sub>SNS</sub> =20mΩ                                                                                             | 27   | 30   | 33   | mV   |
| Charge Termination        |                                                                    |                                                                                                                    |      |      |      |      |
| K <sub>TERM</sub>         | Termination set factor                                             | Termination of fast charge current                                                                                 |      | 10   |      | %    |
| t <sub>TERM_DEG</sub>     | Deglitch time                                                      | V <sub>BAT</sub> > V <sub>RCH</sub> and I <sub>CHG</sub> < I <sub>TERM</sub>                                       |      | 1.3  |      | S    |

| Symbol                                            | Parameter                                                                                   | Condition                                            | SPEC |      |      | Unit |
|---------------------------------------------------|---------------------------------------------------------------------------------------------|------------------------------------------------------|------|------|------|------|
|                                                   |                                                                                             |                                                      | Min. | Typ. | Max. |      |
| Input Under-Voltage Lock-Out Comparator (UVLO)    |                                                                                             |                                                      |      |      |      |      |
| V <sub>UVLO</sub>                                 | AC under-voltage rising                                                                     | Measure on IN                                        |      | 4.1  |      | V    |
| V <sub>UVLO-HSY</sub>                             | AC under-voltage                                                                            | Measure on IN                                        |      | 3.9  |      | V    |
| Sleep Comparator (Reverse Discharging Protection) |                                                                                             |                                                      |      |      |      |      |
| V <sub>SLEEP</sub>                                | Sleep mode threshold                                                                        | V <sub>IN</sub> -V <sub>BAT</sub> falling            |      | 50   |      | mV   |
| V <sub>SLEEP-HYS</sub>                            | Hysteresis                                                                                  | V <sub>IN</sub> -V <sub>BAT</sub> rising             |      | 250  |      | mV   |
| t <sub>SLEEP-DC</sub>                             | Deglintch to disable charge                                                                 | V <sub>IN</sub> -V <sub>BAT</sub> falling            |      | 1    |      | mS   |
| t <sub>SLEEP-FALL</sub>                           | Deglintch to enter Sleep                                                                    | V <sub>IN</sub> -V <sub>BAT</sub> falling            |      | 1    |      | mS   |
| t <sub>SLEEP-RISE</sub>                           | Deglintch to exit Sleep                                                                     | V <sub>IN</sub> -V <sub>BAT</sub> rising             |      | 1.3  |      | S    |
| Bat Low Comparator                                |                                                                                             |                                                      |      |      |      |      |
| V <sub>LOWV</sub>                                 | Pre-charge to fast charge transition threshold                                              | 1 cell, measured on BAT                              | 2.8  | 2.9  | 3.0  | V    |
|                                                   |                                                                                             | 2 cells, measured on BAT                             | 5.7  | 5.8  | 5.9  | V    |
| V <sub>LOWV-HYS</sub>                             | Fast charge to pre-charge hysteresis                                                        | 1 cell, measured on BAT                              |      | 100  |      | mV   |
|                                                   |                                                                                             | 2 cells, measured on BAT                             |      | 200  |      | mV   |
| t <sub>pre2fast</sub>                             | V <sub>LOWV</sub> rising deglitch                                                           | Delay to start fast charge current                   |      | 25   |      | mS   |
| t <sub>fast2pre</sub>                             | V <sub>LOWV</sub> falling deglitch                                                          | Delay to start pre-charge current                    |      | 25   |      | mS   |
| V <sub>SHORT</sub>                                | Battery short voltage                                                                       | measured on BAT                                      |      | 2.2  |      | V    |
| V <sub>SHORT_HY</sub>                             | Battery short voltage hysteresis                                                            | measured on BAT                                      |      | 2.4  |      | V    |
| I <sub>SHORT</sub>                                | Battery short bias                                                                          |                                                      |      | 10   |      | mA   |
| Re-Charge Comparator                              |                                                                                             |                                                      |      |      |      |      |
| V <sub>RECHG</sub>                                | Re-charge Threshold, below regulation voltage limit, V <sub>BAT-REG</sub> -V <sub>BAT</sub> | 2 cells, measured on BAT                             | 50   | 100  | 150  | mV   |
|                                                   |                                                                                             | 2 cells, measured on BAT                             | 100  | 130  | 160  | mV   |
| t <sub>RECH-RISE_DEG</sub>                        | V <sub>RECHG</sub> rising deglitch                                                          | V <sub>BAT</sub> decreasing below V <sub>RECHG</sub> |      | 25   |      | mS   |



| Symbol                      | Parameter                                                     | Condition                                                          | SPEC |      |      | Unit |
|-----------------------------|---------------------------------------------------------------|--------------------------------------------------------------------|------|------|------|------|
|                             |                                                               |                                                                    | Min. | Typ. | Max. |      |
| $t_{RECH-FALL\_DEG}$        | $V_{RECHG}$ falling deglitch                                  | $V_{BAT}$ increasing above $V_{RECHG}$                             |      | 25   |      | mS   |
| Bat Over-Voltage Comparator |                                                               |                                                                    |      |      |      |      |
| $V_{OV\_RISE}$              | Over-voltage rising threshold                                 | As percentage of $V_{BAT\_REG}$                                    |      | 110  |      | %    |
| $V_{OV\_FALL}$              | Over-voltage falling threshold                                | As percentage of $V_{BAT}$                                         |      | 105  |      | %    |
| Thermal Regulation          |                                                               |                                                                    |      |      |      |      |
| $T_{J\_REG}$                | Junction Temperature                                          | Charging                                                           |      | 125  |      | °C   |
| Thermal Shutdown Comparator |                                                               |                                                                    |      |      |      |      |
| $T_{SHUT}$                  | Thermal shutdown temperature                                  | Temperature rising                                                 |      | 155  |      | °C   |
| $T_{SHUT-HYS}$              | Thermal shutdown hysteresis                                   | Temperature falling                                                |      | 30   |      | °C   |
| $t_{SHUT-RISE-DEG}$         | Thermal shutdown deglitch                                     | Temperature rising                                                 |      | 25   |      | uS   |
| Thermistor Comparator       |                                                               |                                                                    |      |      |      |      |
| $I_{TS}$                    | TS bias current                                               |                                                                    | 70   | 76   | 82   | μA   |
| $V_{LTF}$                   | Cold temperature threshold, TS pin voltage rising threshold   | Charger suspends charge                                            |      | 3.0  |      | V    |
| $V_{LTF\_HYS}$              | Cold temperature hysteresis, TS pin voltage falling threshold | Charger recovery charge                                            |      | 2.6  |      | V    |
| $V_{HTF}$                   | Hot temperature TS pin voltage falling threshold              | Charger suspends charge                                            |      | 300  |      | mV   |
| $t_{TS-CHG-SUS}$            | Deglitch time for temperature out of range detection          | $V_{TS} > V_{LTF}$ , or $V_{TS} < V_{TCO}$ , or $V_{TS} < V_{HTF}$ |      | 1.3  |      | S    |

| Symbol                                                 | Parameter                                            | Condition                                                                    | SPEC |      |      | Unit |
|--------------------------------------------------------|------------------------------------------------------|------------------------------------------------------------------------------|------|------|------|------|
|                                                        |                                                      |                                                                              | Min. | Typ. | Max. |      |
| $t_{TS-CHG-RSM}$                                       | Deglitch time for temperature out of range detection | $V_{TS} < V_{LTF}-V_{LTF-HYS}$ or $V_{TS} > V_{TCO}$ , or $V_{TS} > V_{HTF}$ |      | 1.3  |      | S    |
| High-Side FET Over-Current Comparator (Cycle by Cycle) |                                                      |                                                                              |      |      |      |      |
| $I_{OCP\_HSFET}$                                       | Current limit on HSFET                               | Measure on HSFET                                                             |      | 4.0  |      | A    |
| Internal PWM                                           |                                                      |                                                                              |      |      |      |      |
| $F_{SW}$                                               | PWM switching frequency                              |                                                                              | 0.80 | 1.0  | 1.05 | MHz  |
| $T_{SW-DEAD}$                                          | Driver dead time                                     | $V_{IN} > 5V$                                                                |      | 50   |      | nS   |
| $R_{DS-HI}$                                            | High Side RON                                        | $V_{BS}-V_{SW}=5V$                                                           |      |      | 150  | mΩ   |
| $R_{DS-LO}$                                            | Low Side RON                                         | $V_{REGN}=5V$                                                                |      |      | 150  | mΩ   |
| Safety Timer                                           |                                                      |                                                                              |      |      |      |      |
| $T_{PRE-CHARGE}$                                       | Pre-charge timer                                     |                                                                              | 52   | 60   | 68   | min  |
| $T_{TAPER-CHARGE}$                                     | Taper-charge timer                                   | $V_{BAT} > V_{RCH}$ and $I_{CHG} < I_{TERM}$ , STAT goes high                | 34   | 40   | 46   | min  |

## Application Information

### 1. Typical Operation Theory

The charger of HM4090 is optimized for charging 1 / 2-cells Li-ion or Li-polymer batteries. It charges a battery with constant current (CC) and constant voltage (CV) profile. In CV mode, if charge current reaches 1/10 constant current threshold, STAT goes Hi to indicate charge full. The typical charge profile is illustrated as below.

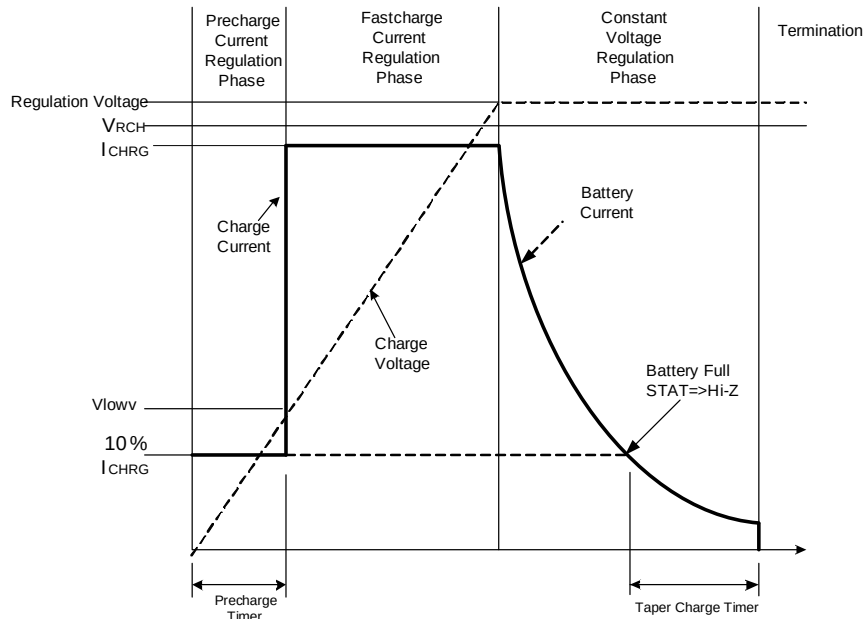


Figure 3. Typical Charging Profile

### 2. Battery Voltage Regulation

The HM4090 offers a high accuracy voltage regulator for the charging voltage. Battery regulation voltage is 4.20V for 1cell and 8.35V for 2cells typ.

### 3. Battery Current Regulation

Battery current is sensed by current sensing resistor  $R_{SNS}$  connected between CS and BAT. The full-scale differential voltage between CS and BAT is 30mV. The equation for charge current is:

$$I_{CHG} = \frac{V_{CS-BAT-CC}}{R_{SNS}}$$

Under high ambient temperature, the charge current will fold back to keep IC temperature not exceeding 125°C.

### 4. Battery Pre-charge Current Regulation

On Power-up, if the battery voltage is below the VLOWV threshold, the HM4090 applies the pre-charge current to the battery. This pre-charge feature is intended to revive deeply discharged cells. If the VLOWV threshold is not reached within 60 mins of initiating pre-charge, the charger turns off and a FAULT is indicated on the status pins.

For HM4090, the pre-charge current is set as 10% of the fast charge rate.

$$I_{PRECHG} = \frac{0.1 * V_{CS-BAT\_CC}}{R_{SNS}}$$

#### 5. Charge Termination

The charger monitors the charging current during the voltage regulation phase. Termination is detected when the BAT voltage is higher than recharge threshold and the charge current is less than the termination current threshold, as calculated below. Termination only indicate “Charge Complete” at STAT pin with Hi and chip will not stop switching charge loop until 40mins taper charge timer expired.

$$I_{TERM} = \frac{0.1 * V_{CS-BAT\_CC}}{R_{SNS}}$$

#### 7. Re-Charge

A new charge cycle is initiated when one of the following conditions occurs:

- The battery voltage falls below the recharge threshold
- A power-on-reset (POR) event occurs
- The battery is removed and reinserted, and then the charge current is above 0.2C.

#### 8. Safety Timers

As a safety backup, the charger also provides an internal fixed 60 minutes pre-charge safety timer. And fixed 40 minutes taper charge timer for additional charge capacity, it start once termination is happened.

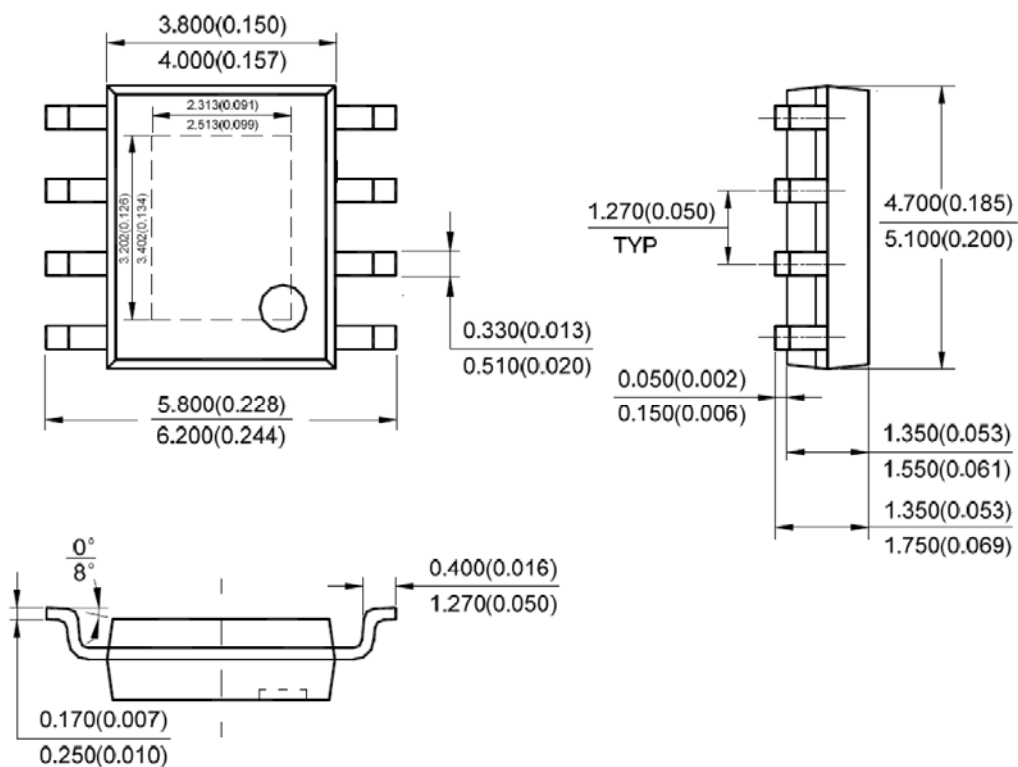
#### 9. Soft-Start Charger Current

The charger automatically soft-starts the charger regulation current every time the charger goes into fast-charge to ensure there is no overshoot or stress on the output capacitors or the power converter. The soft-start consists of stepping-up the charge regulation current into 8 evenly divided steps up to the programmed charge current.

#### 10. Temperature Qualification

The TS pin output a zero TC current to bias a negative temperature coefficient thermistor (TS) which connect to AGND. The controller continuously monitors battery temperature by measuring the voltage between the TS pin and AGND, it compares this voltage against its internal thresholds to determine if charging is allowed. To initiate a charge cycle, the battery temperature must be within the VLTF to VHTF thresholds. If battery temperature is outside of this range, the controller suspends charge and waits until the battery temperature is within the VLTF to VHTF range. The controller suspends charge by turning off the PWM MOSFETs. A 10K TS with B-Constant around 3950k is recommended for application.

Package Information(SOP8-e)



## Classification Reflow Profiles

| Profile Feature                                                                                   | Pb-Free Assembly |
|---------------------------------------------------------------------------------------------------|------------------|
| Preheat & Soak Temperature min (T <sub>smin</sub> ) Temperature max (T <sub>smax</sub> )          | 150°C<br>200°C   |
| Time (T <sub>smin</sub> to T <sub>smax</sub> ) (t <sub>s</sub> )                                  | 60-120 seconds   |
| Average ramp-up rate (T <sub>smax</sub> to T <sub>p</sub> )                                       | 3°C/second max.  |
| Liquidous temperature (T <sub>L</sub> )                                                           | 217°C            |
| Time at liquidous (t <sub>L</sub> )                                                               | 60-150 seconds   |
| Peak package body temperature (T <sub>p</sub> )*                                                  | Max 260°C        |
| Time (t <sub>p</sub> )** within 5°C of the specified classification temperature (T <sub>c</sub> ) | Max 30 seconds   |
| Average ramp-down rate (T <sub>p</sub> to T <sub>smax</sub> )                                     | 6°C/second max.  |
| Time 25°C to peak temperature                                                                     | 8 minutes max.   |

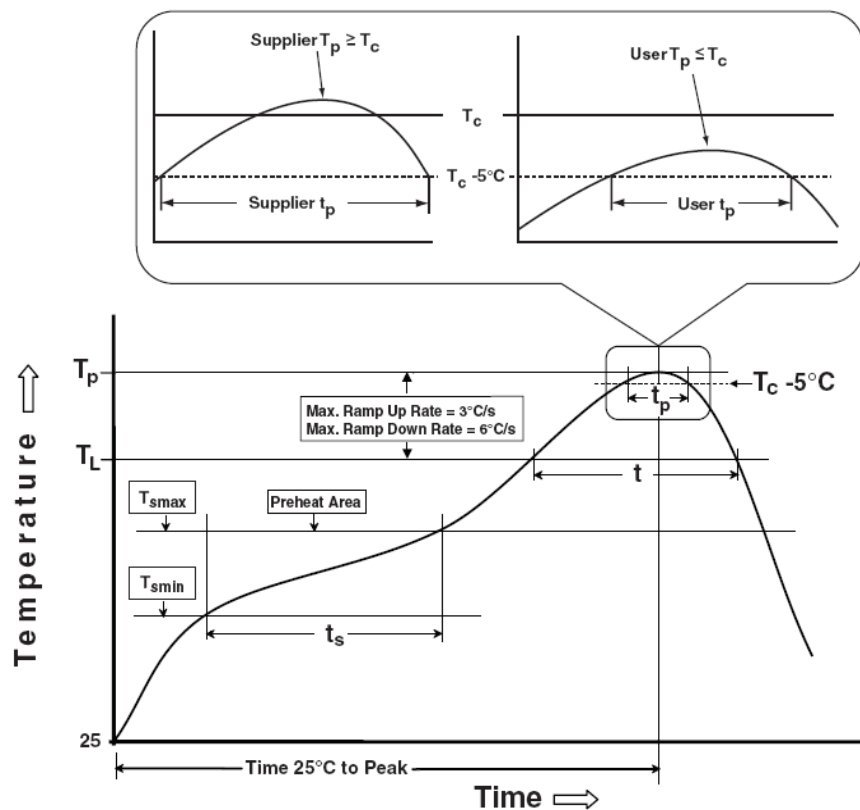


Figure 21. Classification Profile

## CAUTION

### Storage Conditions

1) This product should be used within 12 months after delivered. Store in manufacturer's package keeping the seal of aluminum coated baggage or tightly re-closed box with the following conditions.

[Temperature: 8°C ... 30°C, Humidity: 30% ... 70% R.H.]

2) Keep the seal of aluminum coated baggage immediately before usage.

3) After breaking the seal of aluminum coated baggage, this product should be used within 1 week on the following conditions.

[Temperature: ≤ 30°C, Humidity: ≤ 60% R.H.]