# 3A Synchronous Buck Li-ion Charger

## General Description

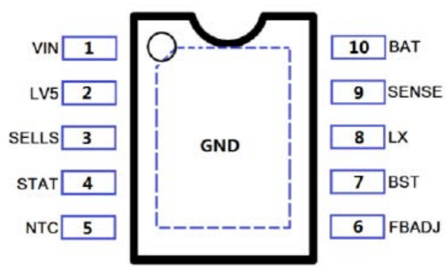
The HM4096 is a 3A Li-Ionbattery charger.Itutilizes a 500KHz synchronous buck converter topology to reduce power dissipation during charging. Low power dissipation, an internal MOSFET allow a physically small charger that can be embedded in a wide range of handheld applications. The HM4096 includes complete charge termination circuitry, automatic recharge and a ±1% 4.2V /8.4V /12.6V /16.8V float voltage.

Battery charge current, charge timeout and end-of-charge indication parameters are set with external components. Additional features include shorted cell detection; temperature qualified charging and overvoltage protection. The HM4096 is available in a low profile ESOP10 package.

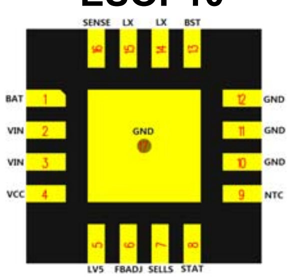
## Features

- Input voltage range 4V~22V
- Dynamic input current allocation for maximum charging rate
- 3.0A Maximum Charge Current
- No External MOSFETs and Blocking Diode Required
- Efficiency up to 90%
- Constant-Current/Constant-Voltage Operation with Thermal Regulation to Maximize Charge Rate Without Risk of Overheating
- Optional Battery Temperature Monitoring Before and During Charge Automatic Sleep Mode for Low-Power
- Over Current Protection
- Consumption Available in ESOP10
- RoHS Compliant and 100% Lead (Pb)-Free

## Functional Pin Description

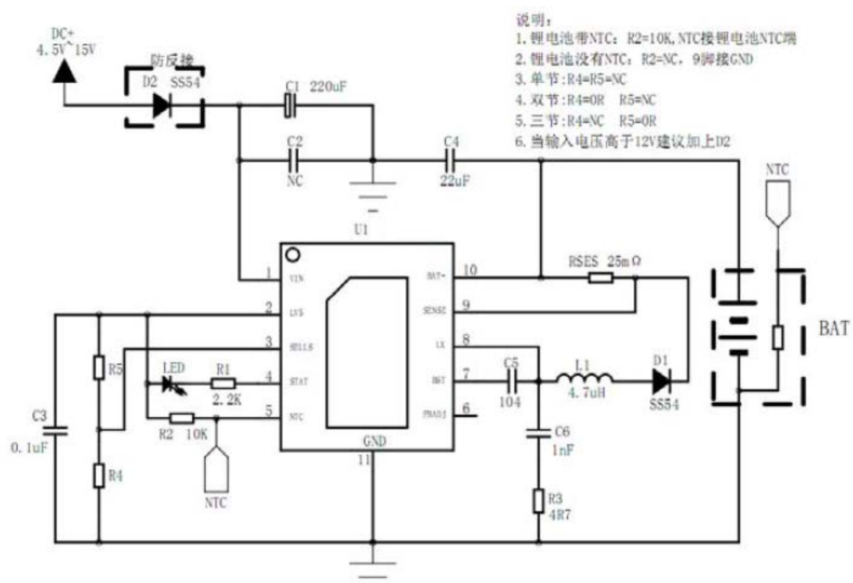



ESOP10




QFN16

## Typical Application Circuit




## Applications

- ✧ Portable Media Players
- ✧ Cellular and Smart mobile phone
- ✧ PDA/DSC
- ✧ Handheld Battery-Powered Devices
- ✧ Handheld Computers
- ✧ Charging Docks and Cradles

## Ordering Information

| Order Number | Package Type | Float Voltage | Packing |
|---|---|---|---|
| HM4096E | ESOP10 | 4.20V/8.4V/12.6V（三合一） | 3000PCS/Pack |
| HM4096Q | QFN16 | 4.20V/8.4V/12.6V（三合一） | 3000PCS/Pack |
| HM4096AQ | QFN16 | 16.80V（四节锂电专用） | 3000PCS/Pack |

## Pin Description

| Pin Name | PIN Number | | Description |
|---|---|---|---|
| | ESOP10 | QFN16 | |
| VIN | 1 | 2,3 | Positive Supply Voltage Input. Decouple with a 220µF or larger electrolytic capacitor. |
| VCC | | 4 | IC Supply Voltage Input. |
| LV5 | 2 | 5 | 5V LDO output PIN. Connect a minimum 1uF capacitor between this PIN and GND. |
| SELLS | 3 | 7 | Floating for 1 cells Lithium ion batteries charger.<br>Connect to GND for 2 cells Lithium ion batteries charger.<br>Connect to LV5 for 3 cells Lithium ion batteries charger. |
| STAT | 4 | 8 | Open-Drain Charge Status Output. When the battery is charging, this pin is pulled low by an internal N-channel MOSFET. When the HM4096 detects an under voltage lockout condition, STAT is forced high impedance. |
| NTC | 5 | 9 | NTC (Negative Temperature Coefficient) Thermistor Input. This pin senses the temperature of the battery pack and stops the charger when the temperature is out of range.Connect to GND for disabling this function. |
| FBADJ | 6 | 6 | CV adjust PIN.<br>Connect resistor to GND increase CV voltage.<br>Connect resistor to VBAT decrease CV voltage. |
| BST | 7 | 13 | Internal charge pump boost pin. |
| LX | 8 | 14,15 | Switch pin. Connect to external inductor. |
| SENSE | 9 | 16 | Detecting pin of charge current. |
| VBAT | 10 | 1 | Battery pin. Connect to bat+. |
| GND | Thermal PAD | 10,11,12,17 | Thermal PAD . Connect to Ground. |

## Absolute Maximum Ratings Note 1

- ✧ VIN /VBAT/SNS/LX to GND ------------------------------------------------------------28V
- ✧ BST to LX ------------------------------------------------------------6.5V
- ✧ ALL OTHER PINS to GND ------------------------------------------------------------6.5V
- ✧ Maximum Junction Temperature ------------------------------------------------------------ 150℃
- ✧ Operating Ambient Temperature Range ($T_A$) ------------------------------------------------------------ -40℃ to 85℃
- ✧ Storage Temperature ------------------------------------------------------------ -45℃ to 165℃
- ✧ Maximum Soldering Temperature (at leads, 10 sec) ------------------------------------------------------------ 260℃

**Note 1.** Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## Thermal Information

- ✧ Maximum Power Dissipation (ESOP10, $P_D$, $T_A$=25℃) ------------------------------------------------------------ 2W
- ✧ Thermal Resistance (ESOP10, $\theta_{JA}$) ------------------------------------------------------------ 50℃/W

## ESD Susceptibility

- ✧ HBM(Human Body Mode) ------------------------------------------------------------ 2KV
- ✧ MM(Machine Mode) ------------------------------------------------------------ 200V

## Electrical Characteristics

**(HM4096E/HM4096Q for 4.20V,TA=25.,VIN=5V, unless other wise noted.)**

Floating for 1 cells Lithium ion batteries charger.

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Adapter/USB Voltage Range | | 4.5 | | 22 | V |
| $I_{CC}$ | Input Supply Current | Standby Mode (Charge Terminated) | | 1 | | mA |
| $V_{FLOAT}$ | Regulated Output (Float) Voltage | FBADJ floating | 4.158 | 4.2 | 4.242 | V |
| $V_{RS}$ | Program Charging Current (For RS to BAT) | $V_{TRIKL}$<$V_{BAT}$<$V_{FLOAT}$ | | 50 | | mV |
| $I_{BAT}$ | BAT Pin Current | $R_{SNS}$=50mΩ, Current Mode | | 1000 | | mA |
| | | $R_{SNS}$=25mΩ, Current Mode | | 2000 | | mA |
| | | Standby Mode | | 4 | | μA |
| $I_{TRIKL}$ | Trickle Charge Current | $V_{BAT}$<$V_{TRIKL}$, $R_{SNS}$=50mΩ | | 100 | | mA |
| | | $V_{BAT}$<2.3V | | 20 | | mA |
| $V_{TRIKL}$ | Trickle Charge Threshold Voltage | $R_{SNS}$=50mΩ, $V_{BAT}$ Rising | | 2.8 | | V |
| $V_{TRHYS}$ | Trickle Charge Hysteresis Voltage | $R_{SNS}$=50mΩ | | 100 | | mV |
| $V_{STAT}$ | STAT Pin Output Low Voltage | $I_{STAT}$=5mA | | | 0.5 | V |
| $I_{STAT}$ | STAT Pin Weak Pull-Down Current | $V_{STAT}$=5V | | | 5 | uA |
| $\Delta V_{RECH}$ | Recharge Battery Threshold | $V_{FLOAT}$-$V_{RECHRG}$ | | 150 | | mV |
| $T_{LIM}$ | Junction Temperature in Constant Temperature Mode | | | 150 | | ℃ |
| $I_{TERM}$ | C/10 Terminal Current | $R_{SNS}$=50mΩ | | 100 | | mA |
| VIN UVLO | Under Voltage Lockout of VIN | $V_{IN}$ rising | | 4 | | V |
| | | $V_{IN}$ falling | | 3.8 | | V |
| VIN OVP | VIN over voltage protect | VIN rising | | 25 | | V |
| | | hysteresis | | 1 | | |
| $V_{NTC-H}$ | High Temperature Protection Threshold Voltage | Battery Temperature rising | | 30 | | $\%V_{LV5}$ |
| $V_{NTC-L}$ | Low Temperature Protection Threshold Voltage | Battery Temperature falling | | 70 | | $\%V_{LV5}$ |
| $F_{OSC}$ | Frequency | | | 500 | | KHz |

## Electrical Characteristics

**(HM4096E/HM4096Q for 8.40V,TA=25.,VIN=12V,unless other wise noted.)**

SELLS pin **connect to GND for 2 cells Lithium ion batteries charger.**

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Adapter/USB Voltage Range | | 8.7 | | 22 | V |
| $I_{CC}$ | Input Supply Current | Standby Mode (Charge Terminated) | | 1 | | mA |
| $V_{FLOAT}$ | Regulated Output (Float) Voltage | FBADJ floating | 8.316 | 8.40 | 8.484 | V |
| $V_{RS}$ | Program Charging Current (For RS to BAT) | $V_{TRIKL}<V_{BAT}<V_{FLOAT}$ | | 50 | | mV |
| $I_{BAT}$ | BAT Pin Current | $R_{SNS}$=50mΩ, Current Mode | | 1000 | | mA |
| | | $R_{SNS}$=25mΩ, Current Mode | | 2000 | | mA |
| | | Standby Mode | | 4 | | μA |
| $I_{TRIKL}$ | Trickle Charge Current | $V_{BAT}<V_{TRIKL}$, $R_{SNS}$=50mΩ | | 100 | | mA |
| | | $V_{BAT}$<2.3V | | 20 | | mA |
| $V_{TRIKL}$ | Trickle Charge Threshold Voltage | $R_{SNS}$=50mΩ, $V_{BAT}$ Rising | | 2.8 | | V |
| $V_{TRHYS}$ | Trickle Charge Hysteresis Voltage | $R_{SNS}$=50mΩ | | 100 | | mV |
| $V_{STAT}$ | STAT Pin Output Low Voltage | $I_{STAT}$=5mA | | | 0.5 | V |
| $I_{STAT}$ | STAT Pin Weak Pull-Down Current | $V_{STAT}$=5V | | | 5 | uA |
| $\Delta V_{RECH}$ | Recharge Battery Threshold | $V_{FLOAT}-V_{RECHRG}$ | | 150 | | mV |
| $T_{LIM}$ | Junction Temperature in Constant Temperature Mode | | | 150 | | ℃ |
| $I_{TERM}$ | C/10 Terminal Current | $R_{SNS}$=50mΩ | | 100 | | mA |
| VIN UVLO | Under Voltage Lockout of VIN | $V_{IN}$ rising | | 4 | | V |
| | | $V_{IN}$ falling | | 3.8 | | V |
| VIN OVP | VIN over voltage protect | VIN rising | | 25 | | V |
| | | hysteresis | | 1 | | |
| $V_{NTC-H}$ | High Temperature Protection Threshold Voltage | Battery Temperature rising | | 30 | | $\%V_{LV5}$ |
| $V_{NTC-L}$ | Low Temperature Protection Threshold Voltage | Battery Temperature falling | | 70 | | $\%V_{LV5}$ |
| $F_{OSC}$ | Frequency | | | 500 | | KHz |

## Electrical Characteristics

**(HM4096E/HM4096Q for 12.60V,TA=25.,VIN=15V,unless other wise noted.)**

**SELLS pin connect to LV5 for 3 cells Lithium ion batteries charger.**

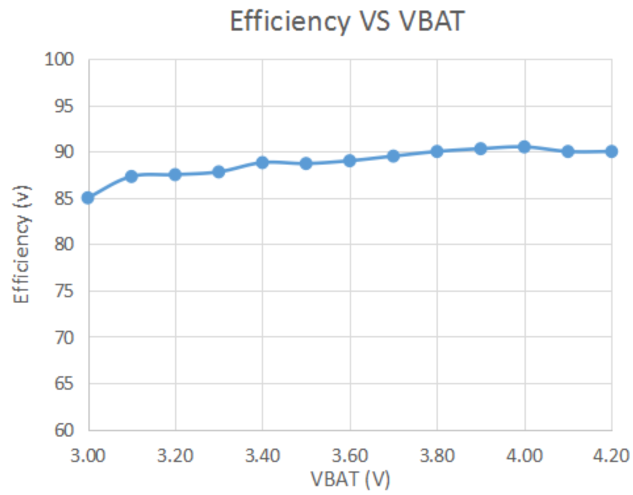
| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Adapter/USB Voltage Range | | 13.6 | 15 | 22 | V |
| $I_{CC}$ | Input Supply Current | Standby Mode (Charge Terminated) | | 1 | | mA |
| $V_{FLOAT}$ | Regulated Output (Float) Voltage | FBADJ floating | 12.474 | 12.60 | 12.726 | V |
| $V_{RS}$ | Program Charging Current (For RS to BAT) | $V_{TRIKL}$<$V_{BAT}$<$V_{FLOAT}$ | | 50 | | mV |
| $I_{BAT}$ | BAT Pin Current | $R_{SNS}$=50mΩ, Current Mode | | 1000 | | mA |
| | | $R_{SNS}$=25mΩ, Current Mode | | 2000 | | mA |
| | | Standby Mode | | 4 | | μA |
| $I_{TRIKL}$ | Trickle Charge Current | $V_{BAT}$<$V_{TRIKL}$, $R_{SNS}$=50mΩ | | 100 | | mA |
| | | $V_{BAT}$<2.3V | | 20 | | mA |
| $V_{TRIKL}$ | Trickle Charge Threshold Voltage | $R_{SNS}$=50mΩ, $V_{BAT}$ Rising | | 2.8 | | V |
| $V_{TRHYS}$ | Trickle Charge Hysteresis Voltage | $R_{SNS}$=50mΩ | | 100 | | mV |
| $V_{STAT}$ | STAT Pin Output Low Voltage | $I_{STAT}$=5mA | | | 0.5 | V |
| $I_{STAT}$ | STAT Pin Weak Pull-Down Current | $V_{STAT}$=5V | | | 5 | uA |
| $\Delta V_{RECH}$ | Recharge Battery Threshold | $V_{FLOAT}$-$V_{RECHRG}$ | | 150 | | mV |
| $T_{LIM}$ | Junction Temperature in Constant Temperature Mode | | | 150 | | ℃ |
| $I_{TERM}$ | C/10 Terminal Current | $R_{SNS}$=50mΩ | | 100 | | mA |
| VIN UVLO | Under Voltage Lockout of VIN | $V_{IN}$ rising | | 4 | | V |
| | | $V_{IN}$ falling | | 3.8 | | V |
| VIN OVP | VIN over voltage protect | VIN rising | | 25 | | V |
| | | hysteresis | | 1 | | |
| $V_{NTC-H}$ | High Temperature Protection Threshold Voltage | Battery Temperature rising | | 30 | | %$V_{LV5}$ |
| $V_{NTC-L}$ | Low Temperature Protection Threshold Voltage | Battery Temperature falling | | 70 | | %$V_{LV5}$ |
| $F_{OSC}$ | Frequency | | 400 | 500 | 600 | KHz |

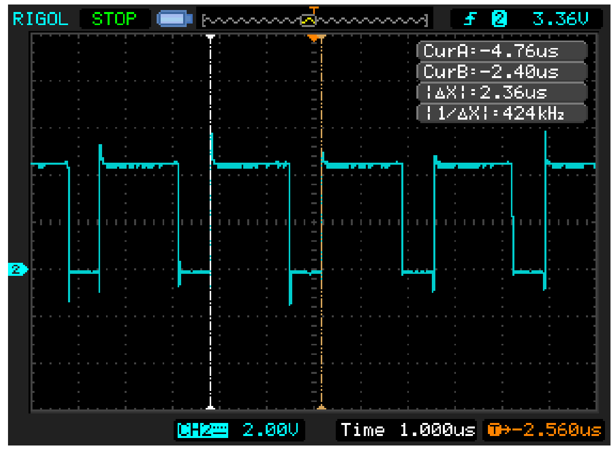
## Electrical Characteristics

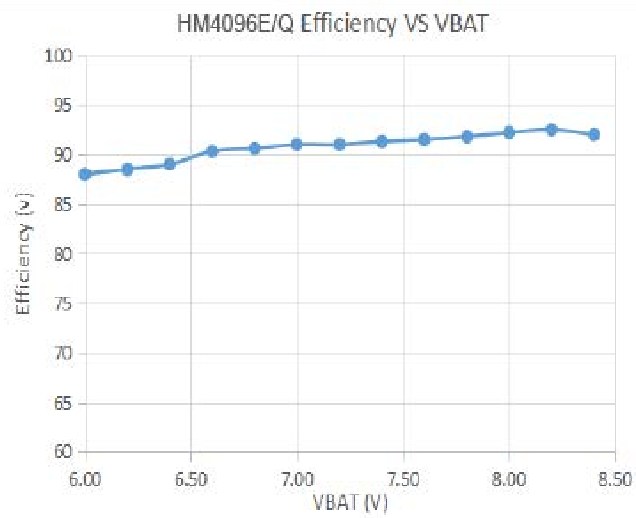
**(HM4096AQ-16.80V,TA=25.,VIN=18V,unless other wise noted.)**

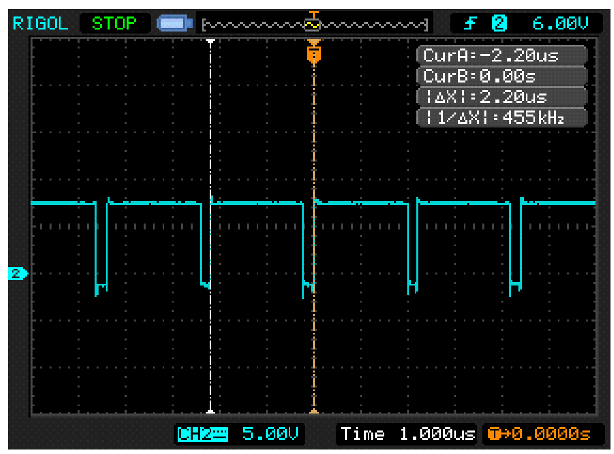
| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Adapter/USB Voltage Range | | 18 | 20 | 22 | V |
| $I_{CC}$ | Input Supply Current | Standby Mode (Charge Terminated) | | 1 | | mA |
| $V_{FLOAT}$ | Regulated Output (Float) Voltage | FBADJ floating | 16.63 | 16.80 | 16.97 | V |
| $V_{RS}$ | Program Charging Current (For RS to BAT) | $V_{TRIKL}$<$V_{BAT}$<$V_{FLOAT}$ | | 50 | | mV |
| $I_{BAT}$ | BAT Pin Current | $R_{SNS}$=50mΩ, Current Mode | | 1000 | | mA |
| | | $R_{SNS}$=25mΩ, Current Mode | | 2000 | | mA |
| | | Standby Mode | | 4 | | μA |
| $I_{TRIKL}$ | Trickle Charge Current | $V_{BAT}$<$V_{TRIKL}$, $R_{SNS}$=50mΩ | | 100 | | mA |
| | | $V_{BAT}$<2.3V | | 20 | | mA |
| $V_{TRIKL}$ | Trickle Charge Threshold Voltage | $R_{SNS}$=50mΩ, $V_{BAT}$ Rising | | 2.8 | | V |
| $V_{TRHYS}$ | Trickle Charge Hysteresis Voltage | $R_{SNS}$=50mΩ | | 100 | | mV |
| $V_{STAT}$ | STAT Pin Output Low Voltage | $I_{STAT}$=5mA | | | 0.5 | V |
| $I_{STAT}$ | STAT Pin Weak Pull-Down Current | $V_{STAT}$=5V | | | 5 | uA |
| $\Delta V_{RECH}$ | Recharge Battery Threshold | $V_{FLOAT}$-$V_{RECHRG}$ | | 150 | | mV |
| $T_{LIM}$ | Junction Temperature in Constant Temperature Mode | | | 150 | | ℃ |
| $I_{TERM}$ | C/10 Terminal Current | $R_{SNS}$=50mΩ | | 100 | | mA |
| VIN UVLO | Under Voltage Lockout of VIN | $V_{IN}$ rising | | 4 | | V |
| | | $V_{IN}$ falling | | 3.8 | | V |
| VIN OVP | VIN over voltage protect | VIN rising | | 25 | | V |
| | | hysteresis | | 1 | | |
| $V_{NTC-H}$ | High Temperature Protection Threshold Voltage | Battery Temperature rising | | 30 | | %$V_{LV5}$ |
| $V_{NTC-L}$ | Low Temperature Protection Threshold Voltage | Battery Temperature falling | | 70 | | %$V_{LV5}$ |
| $F_{OSC}$ | Frequency | | 400 | 500 | 600 | KHz |

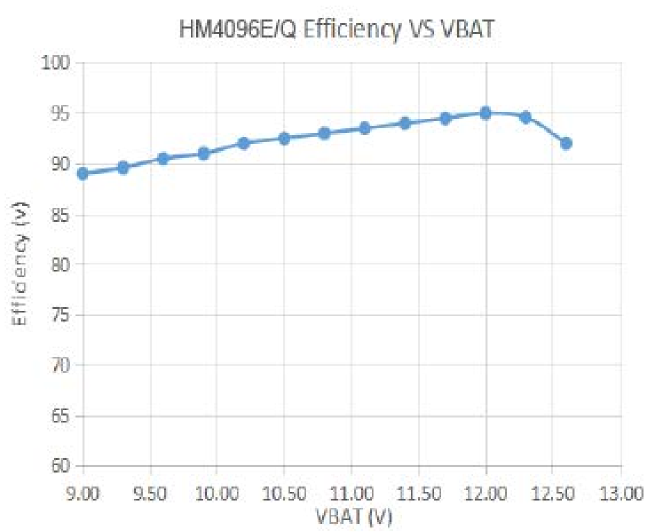
## Typical Operating Preformance

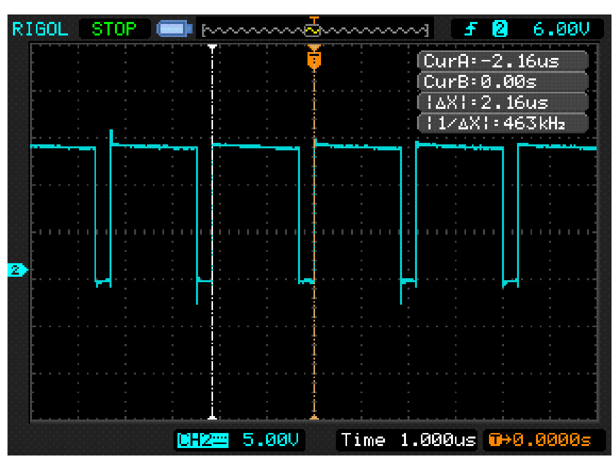


## Application Information:

HM4096 is a wide range VIN(4V-20V),3.0A 1/2/3/4-cells asynchronous boost Li-Ion battery charger integrates 500KHz switching frequency and full protection functions. The charge current can be programmed up to 3.0A by using the external resistor for different portable applications and indicates the charger current information simultaneous. In constant current mode, the charge current is set by the external sense resistor $R_{SNS}$ and an internal 50mV reference;

$I_{BAT}=V_{RS}/R_{SNS}=50mV/R_{SNS}$

When the battery voltage approaches the programmed float voltage, the charge current will start to decrease. When the current drops to 10% of the full-scale charge current, an internal comparator turns off charging is terminated.

**Input Source Qualification:**

After REGN amplifier powers up, the HM4096 checks the current capability of the input source. The input source has to meet the VREG>1V to enable the chip

**Battery Temperature Detection:**

The HM4096 continuously monitors temperature by measuring the voltage between the NTC and GND pins. A negative or a positive temperature coefficient thermistor (NTC, PTC) and an external voltage divider typically develop this voltage. The HM4096 compares this voltage against its internal VNTC-H and VNTC-L thresholds to determine if charging is allowed. The temperature sensing circuit is immune to any fluctuation in LV5, since both the external voltage divider and the internal thresholds (VNTC-H and VNTC-L) are referenced to LV5.

The resistor values of R1 and R2 are calculated by the following equations:

For NTC Thermistors:

K1 (VNTC-H) =30%,

K2 (VNTC-L) =70%.

**Automatic Recharge:**

Once the charge cycle is terminated, the HM4096 continuously monitors the voltage on the BAT pin using a comparator with a 1.8ms filter time ($t_{RECHARGE}$). A charge cycle restarts when the battery voltage falls below 4.05V (which corresponds to approximately 80% to 90% battery capacity). This ensures that the battery is kept at or near a fully charged condition and eliminates the need for periodic charge cycle initiations.

Where RTL is the low temperature resistance and RTH is the high temperature resistance of thermistor, as specified by the thermistor manufacturer. R1 or R2 can be omitted if only one temperature (low or high) setting is required. Applying a voltage between the VNTC-H and VNTC-L thresholds to pin NTC disables the temperature-sensing feature.

**CV adjustment :**

Battery termination voltage default set to 4.2V. If other CV voltage wanted, the follow equations change the CV voltage.

If increase CV voltage, connect a resistor from FBADJ to GND. the increased voltage determined by:

$$\Delta V=\frac{2.1}{R_{trim}}*R_{divup}$$

If decrease CV voltage, connect a resistor from battery to FBADJ, the decreased voltage determined by:

$$\Delta V=\frac{V_{CV}-2.1}{R_{trim}}*R_{divdown}$$

Rdivup=156K

Rdivdown=156K for 1cell

Rdivdown=156K/3 for 2cell

Rdivdown=156K/5 for 3cell

Rdivdown=156K/7 for 4cell

## Shutdown:

The HM4096 can be shut down by pulling the NTC pin to VIN. When the NTC pin is released, the internal timer is reset and a new charge cycle starts.

## Inductor Selection:

A operating frequency was chosen for the buck switcher in order to minimize the size of the inductor. However, take care to use inductors with low core loss at this frequency. To calculate the inductor ripple current.

## Charge Status Indicator (STAT):

The charge status output has two different states: strong pull-down (~5mA) and high impedance. The strong pull-down state indicates that theHM4096 is in a charge cycle. Once the charge cycle has terminated, the pin state is determined by under voltage lockout conditions. High impedance indicates that the charge cycle complete.

## Layout Considerations:

Switch rise and fall times are kept under 5ns for maximum efficiency. To minimize radiation, the SW pin and input bypass capacitor leads (between VIN and GND) should be kept as short as possible. A ground plane should be used under the switching circuitry to prevent inter plane coupling. The Exposed Pad must be connected to the ground plane for proper power dissipation. The other paths contain only DC and/or 500KHz tri-wave ripple current and are less critical. With the exception of the input and output filter capacitors (which should be connected to GND) all other components that return to ground.

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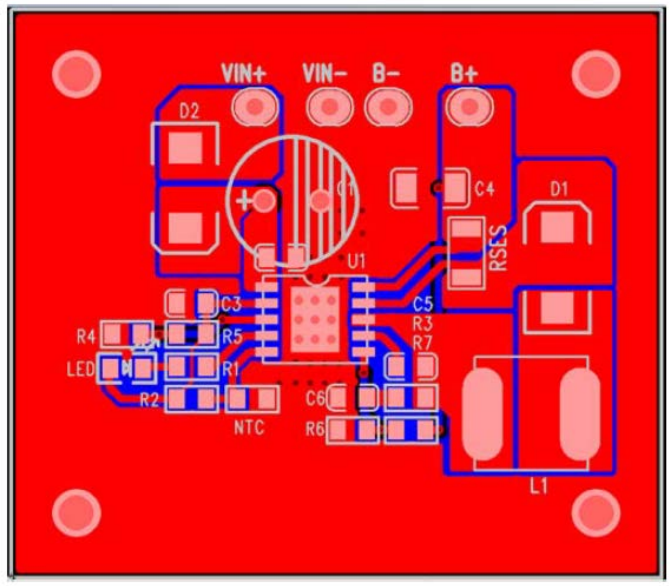
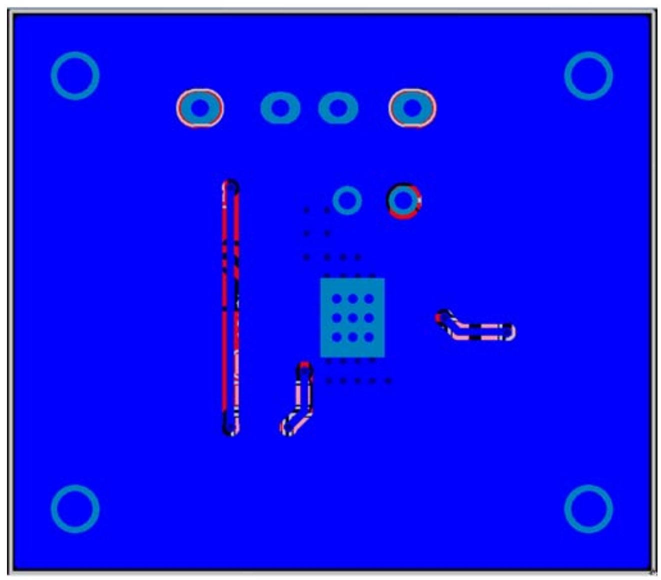
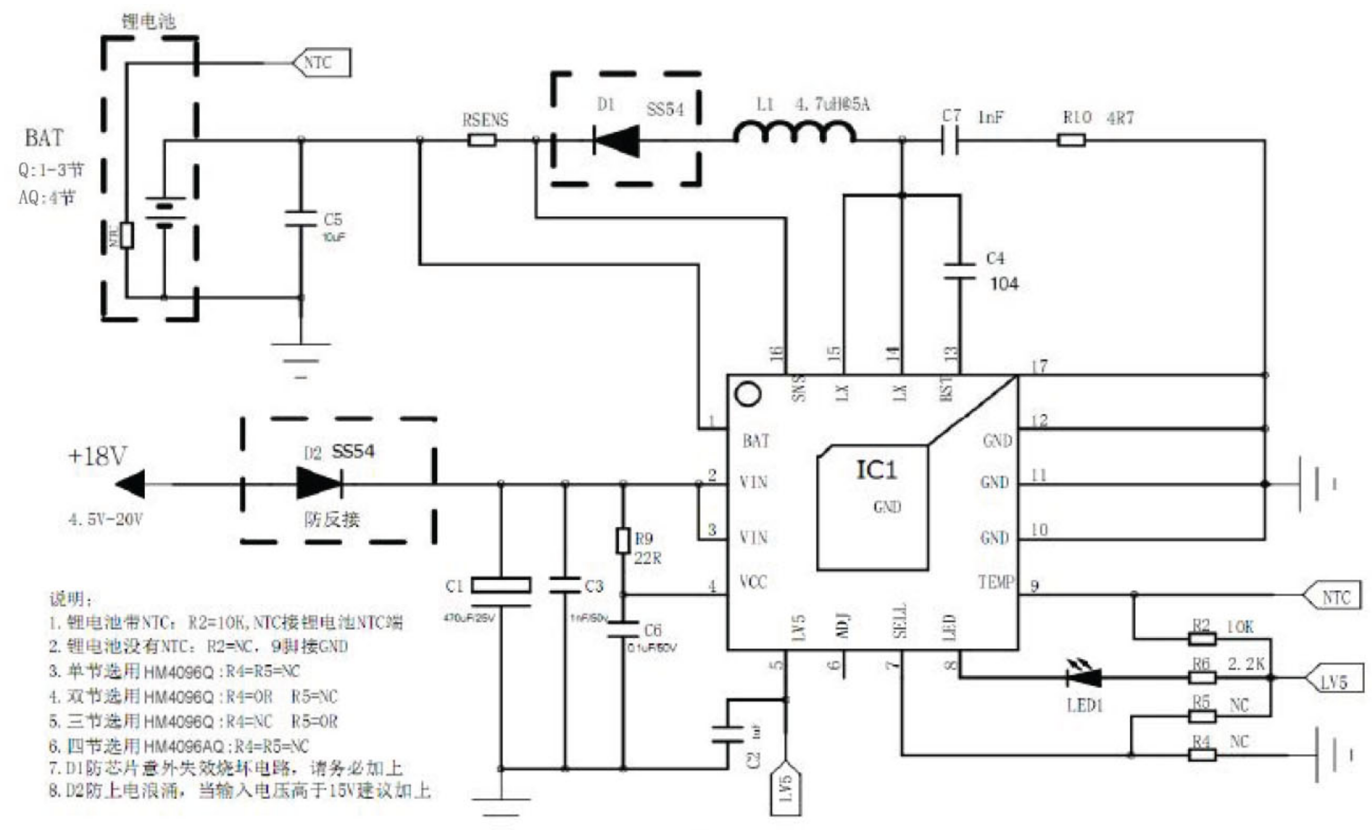
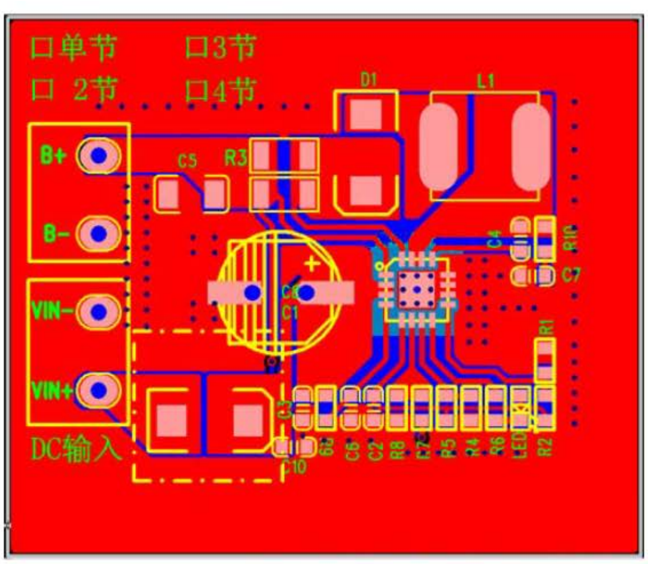


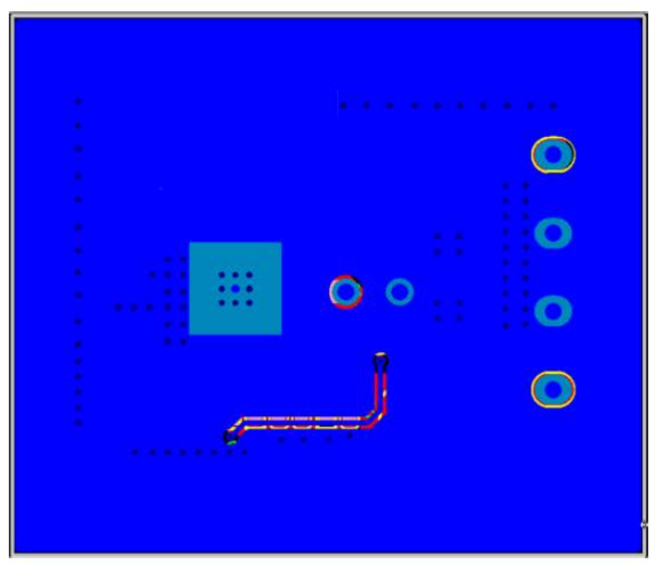



HM4096Q/AQ Typical Application Circuit：

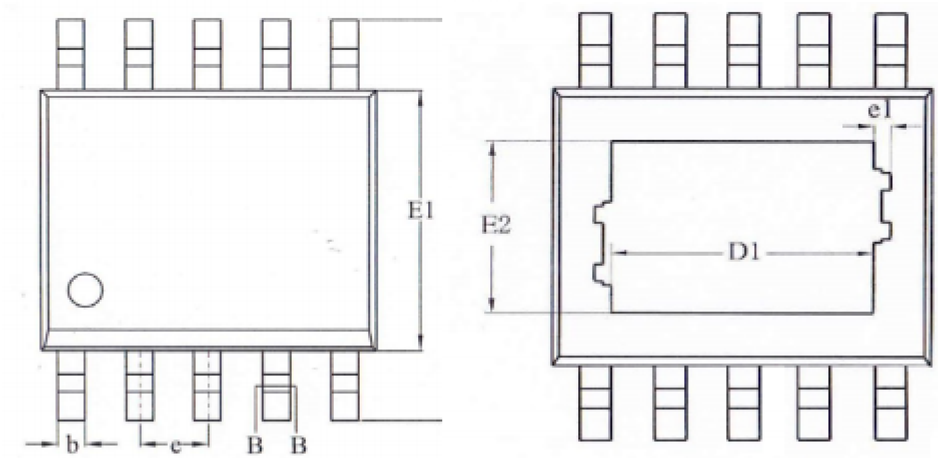


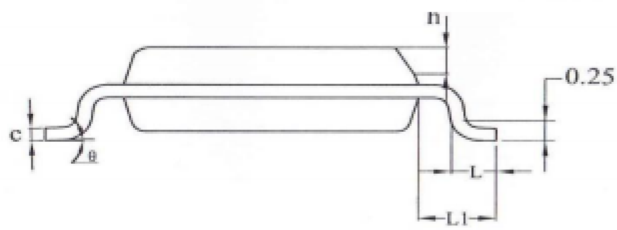

THE DEMO BOARD OF HM4096Q/AQ :

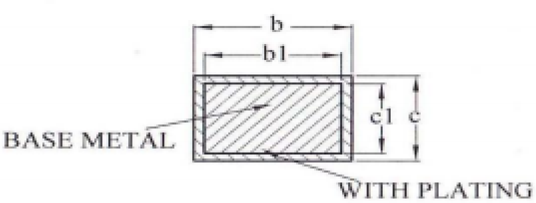


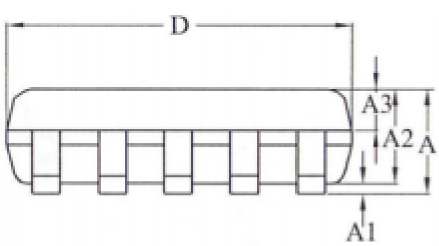



**Fully Functional Application: ESSOP10**

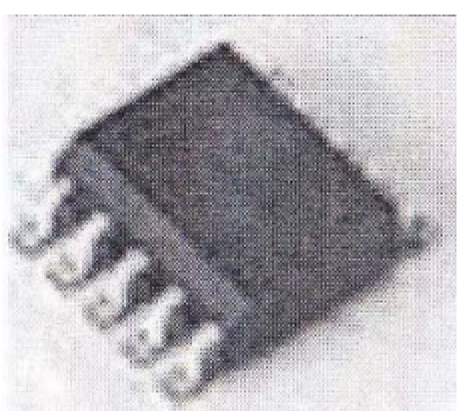


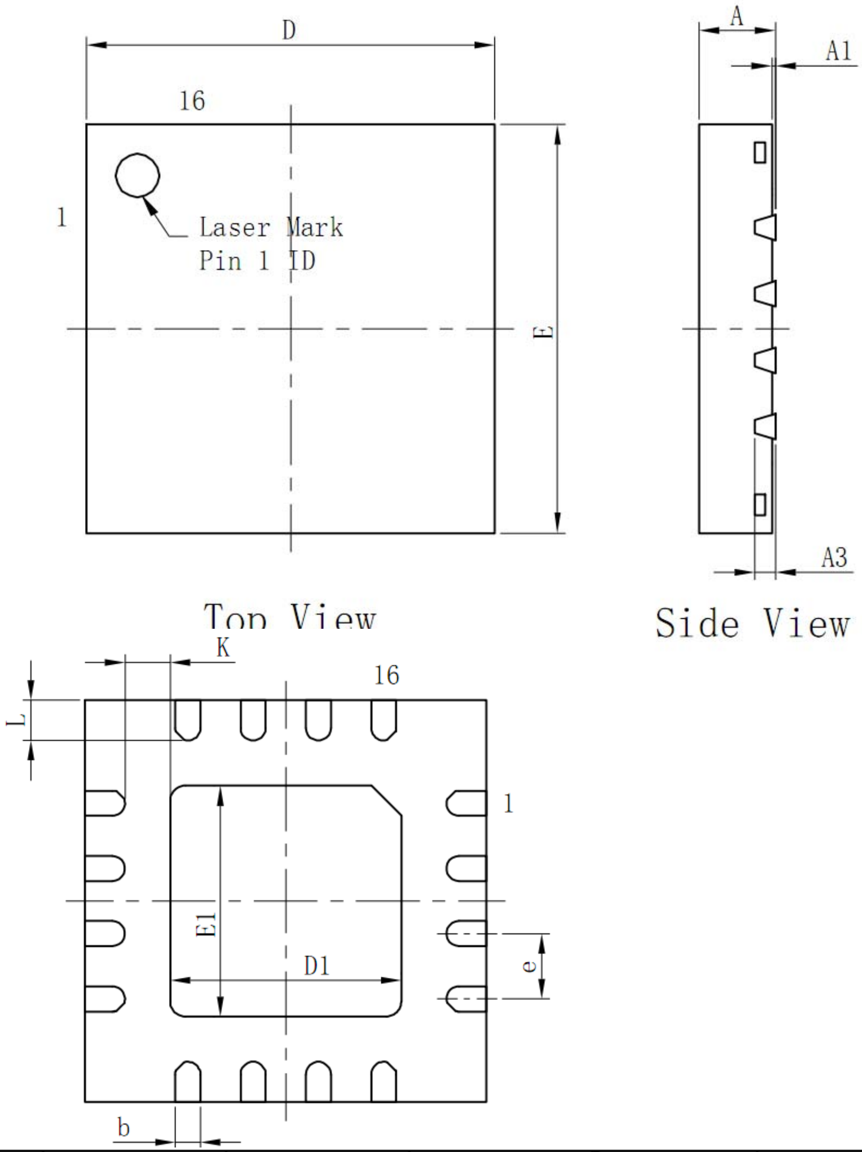




| SYMBOL | MILLIMETER | | |
|---|---|---|---|
| | MIN | NOM | MAX |
| A | — | — | 1.75 |
| A1 | 0.10 | — | 0.225 |
| A2 | 1.30 | 1.40 | 1.50 |
| A3 | 0.60 | 0.65 | 0.70 |
| b | 0.39 | — | 0.47 |
| b1 | 0.38 | 0.41 | 0.44 |
| c | 0.20 | — | 0.24 |
| c1 | 0.19 | 0.20 | 0.21 |
| D | 4.80 | 4.90 | 5.00 |
| E | 5.80 | 6.00 | 6.20 |
| E1 | 3.80 | 3.90 | 4.00 |
| e | 1.00BSC | | |
| h | 0.25 | — | 0.50 |
| L | 0.50 | — | 0.80 |
| L1 | 1.05REF | | |
| θ | 0 | — | 8° |



| Size (mm) / L/F Size (mil) | D1 | E2 | e1 |
|---|---|---|---|
| 90*90 | 2.09REF | 2.09REF | 0.16REF |
| 95*130 | 3.10REF | 2.21REF | 0.10REF |

## Fully Functonal Application: QFN16




| 尺寸 标注 | 最小 | 标准 | 最大 | 尺寸 标注 | 最小 | 标准 | 最大 |
|---|---|---|---|---|---|---|---|
| A | 0.70 | 0.75 | 0.80 | D1 | 2.20 | 2.30 | 2.40 |
| A1 | 0.00 | — | 0.05 | E1 | 2.20 | 2.30 | 2.40 |
| A3 | 0.203REF | | | e | 0.65TYP | | |
| b | 0.20 | 0.25 | 0.30 | K | 0.20 | – | – |
| D | 3.90 | 4.00 | 4.10 | L | 0.30 | 0.40 | 0.50 |
| E | 3.90 | 4.00 | 4.10 | | | | |