

## 2.5A Dual Li-Ion Battery Charger with 2.4A Buck OTG function

### DESCRIPTION

HM4049 is a wide input range, high efficiency, synchronous dual series Li-Ion battery cell boost charger. It accepts input from 2.7V to 7V and is capable of delivering up to 2.5A charge current to two stacked Li-Ion batteries. The charging current and termination voltage can both be programmed through external resistors. There are also an input current limit setting and a dynamic input power management setting. These features can be used for limiting the charging current when a weak power source is plugged in. The boost has a true-shutoff function that disconnects the input from output when short circuit or shut down occurs. A NTC function is also included to configure charging at different temperatures. A STAT function indicates charging status. Furthermore, HM4049 incorporates an OTG function that when enabled, with the same inductor, one can reversely deliver power from the batteries to VBUS. It can deliver up to 2A at 5V.

HM4049 is housed in a tiny QFN3x3-20 package.

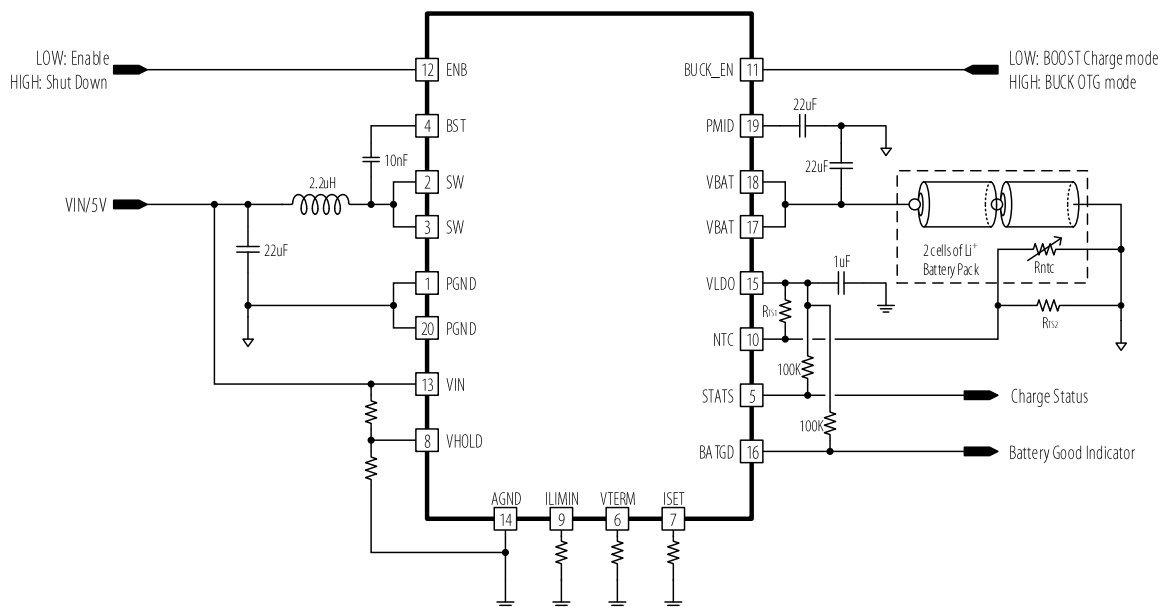
### FEATURES

- ◆ 2.5A Charging with up to 95% Efficiency
- ◆ High voltage input standoff up to 16V
- ◆ Input current limit and DPM setting
- ◆ External programmable CC/CV setting
- ◆ NTC thermistor input
- ◆ Charger status indication
- ◆ True-Shutoff Boost
- ◆ Bi-Directional Power conversion with Single Inductor
- ◆ Tiny QFN3x3 package

### APPLICATIONS

- ◆ E-Cigarette
- ◆ Power Bank
- ◆ Two Cell Li-Ion battery applications

### TYPICAL APPLICATION



### ORDERING INFORMATION

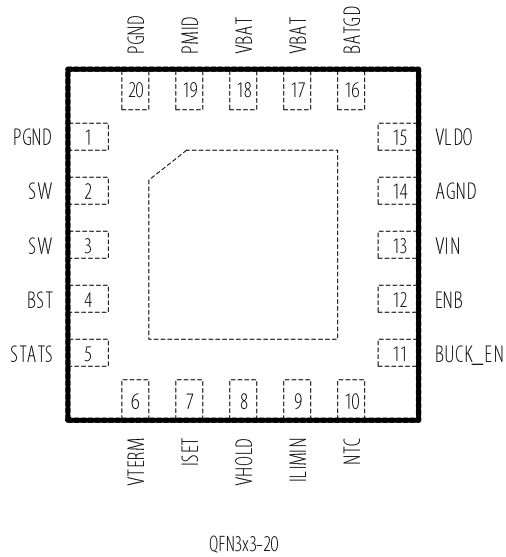
**PART No.**  
HM4049

**PACKAGE**  
QFN3x3-20

**TOP MARK**  
HM4049  
XXXX

**Pcs/Reel**  
5000

## PIN CONFIGURATION



## ABSOLUTE MAXIMUM RATINGS

(Note: Exceeding these limits may damage the device. Exposure to absolute maximum rating conditions for long periods may affect device reliability.)

|                                      |                             |                                  |
|--------------------------------------|-----------------------------|----------------------------------|
| IN Voltage                           | .....                       | -0.3V to 13.2V                   |
| BAT, PMID, SW, STAT Voltage          | .....                       | -0.3V to 16V                     |
| BST Voltage                          | .....                       | $V_{SW} - 0.3V$ to $V_{SW} + 5V$ |
| All Other Pin Voltage                | .....                       | -0.3V to 6V                      |
| SW, IN, BAT, VLDO to ground current  | .....                       | Internally limited               |
| Operating Temperature Range          | .....                       | -40°C to 85°C                    |
| Storage Temperature Range            | .....                       | -55°C to 150°C                   |
| Thermal Resistance                   | $\theta_{JA}$ $\theta_{JC}$ |                                  |
| QFN3X3-20                            | 50    12                    | °C/W                             |
| Lead Temperature (Soldering, 10ssec) | .....                       | 260°C                            |
| ESD HBM (Human Body Mode)            | .....                       | 2KV                              |
| ESD MM (Machine Mode)                | .....                       | 200V                             |

## ELECTRICAL CHARACTERISTICS

( $V_{IN} = 5V$ , unless otherwise specified. Typical values are at  $T_A = 25^\circ C$ .)

| PARAMETER                     | CONDITIONS                                 | MIN  | TYP  | MAX  | UNITS      |
|-------------------------------|--|------|------|------|------------|
| <b>INPUT</b>                  |  |      |      |      |            |
| IN Standoff Voltage           |  |      | 16   |      | V          |
| IN Range                      |  | 2.7  |      | 7    | V          |
| IN UVLO Voltage               | Rising, Hys=300mV                          |      | 2.6  |      | V          |
| IN OVP Voltage                | Hys=500mV                                  |      | 7.1  |      | V          |
| Input Shutdown Current        | $V_{IN} = 5V, V_{BAT} = 0V, ENB = High$    |      | 3    |      | $\mu A$    |
| Battery leakage Current       | $V_{IN} = 0V, V_{BAT} = 8V, ENB = High$    |      | 7    |      | $\mu A$    |
| <b>POWER FETs</b>             |  |      |      |      |            |
| PMID to BAT FET               |  |      | 56   |      | m $\Omega$ |
| PMID to SW FET                |  |      | 56   |      | m $\Omega$ |
| SW to GND FET                 |  |      | 76   |      | m $\Omega$ |
| <b>BOOST BATTERY CHARGER</b>  |  |      |      |      |            |
| Battery CV Voltage            | $R_{VTERM}$ float                          | 8.36 | 8.40 | 8.44 | V          |
|                               | $R_{VTERM} = 10K, I_{BAT} = 0mA$ , default |      | 8.70 |      | V          |
| Charger Restart Threshold     | $V_{CV} = 8.40V$                           |      | -300 |      | mV         |
| Battery Pre-Condition Voltage | $V_{BAT}$ Rising, Hys=230mV                |      | 5.7  |      | V          |
| Pre-Condition Charge Current  | $R_{ISET} = 2.8K\Omega$                    |      | 150  |      | mA         |
| Fast Charge Current           | $R_{ISET} = 8.6K\Omega$                    |      | 0.5  |      | A          |
|                               | $R_{ISET} = 2.8K\Omega$                    |      | 1.5  |      |            |
|                               | $R_{ISET} = 1.7K\Omega$                    |      | 2.5  |      |            |
|                               |  |      |      |      |            |

| PARAMETER                                       | CONDITIONS                             | MIN  | TYP  | MAX  | UNITS      |
|---|--|------|------|------|------------|
| Fast Charge Current Accuracy                    |  | -10  |      | 10   | %          |
| Charge Termination Current                      | $R_{ISET}=2.8K\Omega$                  |      | 150  |      | mA         |
| Input current limit                             | $R_{INLIM}=39K, V_{IN}=5V, V_{BAT}=7V$ |      | 2    |      | A          |
| Input Dynamic Power Threshold                   | $V_{HOLD}$                             |      | 1.1  |      | V          |
| Deep Discharged $V_{BAT}$ protection threshold  | $V_{BAT}-V_{IN}, V_{BAT}$ Falling      |      | 330  |      | mV         |
|   | $V_{BAT}-V_{IN}, V_{BAT}$ Rising       |      | 550  |      | mV         |
| Charge current during Deep Discharged $V_{BAT}$ | $R_{ISET}=2.8K\Omega$                  |      | 150  |      | mA         |
| Pre-Condition Timer                             |  |      | 1    |      | Hour       |
| Fast-Charge Timer                               |  |      | 4.5  |      | Hour       |
| Total Charge Timer                              |  |      | 12   |      | Hour       |
| EOC Delay Time                                  |  |      | 30   |      | ms         |
| Boost switching Frequency                       |  |      | 1    |      | MHz        |
| Boost Cycle-by-Cycle Peak Current limit         |  |      | 7    |      | A          |
| Battery Remove Detection                        |  |      |      |      |            |
| Battery Detection Current                       |  |      | 0.6  |      | mA         |
| Battery Detection Timer                         |  |      | 256  |      | ms         |
| OTG (BUCK MODE)                                 |  |      |      |      |            |
| BATT OK Threshold                               | Rising, HYS=0.5V                       |      | 6    |      | V          |
| Output Voltage Range                            |  | 5.05 | 5.15 | 5.25 | V          |
| Quiescent Current At BATT                       | Buck On                                |      | 350  |      | $\mu A$    |
| Shutdown Supply Current At BATT                 | Idle Mode                              |      | 7    |      | $\mu A$    |
| Switching Frequency                             | $V_{BATT}<4.4V$                        |      | 1    |      | MHz        |
| HS Peak Current Limit                           |  |      | 5    |      | A          |
| Short Circuit Hiccup Timer                      | On Time                                |      | 4    |      | ms         |
|   | Off Time                               |      | 12   |      |            |
| VHOLD, ISET, VCV, ILIMIN                        |  |      |      |      |            |
| VHOLD Threshold                                 | Vout start to reduce charging current  |      | 1.1  |      | V          |
| ISET Voltage                                    | $V_{BAT}<V_{PRECOND}$                  |      | 0.11 |      | V          |
|   | $V_{BAT}>V_{PRECOND}$                  |      | 1.1  |      |            |
| ILIMIN Voltage                                  |  |      | 1.1  |      | V          |
| VCV Internal Pull-up Current                    |  |      | 10   |      | $\mu A$    |
| VLDO  |  |      |      |      |            |
| VLDO Voltage                                    |  |      | 5    |      | V          |
| VLDO Output Current Limit                       |  |      | 75   |      | mA         |
| LOGIC INPUTs BUCKEN, ENB                        |  |      |      |      |            |
| Logic Input High                                |  |      |      | 0.4  | V          |
| Logic Input Low                                 |  | 1.2  |      |      | V          |
| Internal Pull-down Resistance                   |  |      | 2    |      | M $\Omega$ |
| Open Drain Outputs STAT, BATGD                  |  |      |      |      |            |

| PARAMETER              | CONDITIONS      | MIN | TYP | MAX | UNITS   |
|------------------------|-----------------|-----|-----|-----|---------|
| Output Low Voltage     | $I_{SINK}=10mA$ |     |     | 0.1 | V       |
| Output Leakage Current | $V_{HIGH}=5V$   |     |     | 1   | $\mu A$ |

## NTC THERMISTOR MONITOR

|                          |                   |  |     |   |         |
|--------------------------|-------------------|--|-----|---|---------|
| NTC Threshold, Cold      | Charger Suspended |  | 75  |   | %VLDO   |
| NTC Threshold, Hot       | Charger Suspended |  | 25  |   | %VLDO   |
| NTC Threshold Hysteresis |                   |  | 2   |   | %VLDO   |
| NTC Disable Threshold    |                   |  | 0.4 |   | V       |
| NTC Input Leakage        |                   |  | 0   | 5 | $\mu A$ |

## THERMAL PROTECTION

|                                       |                            |  |     |  |             |
|---------------------------------------|----------------------------|--|-----|--|-------------|
| Charging Thermal Regulation threshold |                            |  | 120 |  | $^{\circ}C$ |
| Thermal Shutdown                      | Rising, Hys= $20^{\circ}C$ |  | 160 |  | $^{\circ}C$ |

## PIN DESCRIPTION

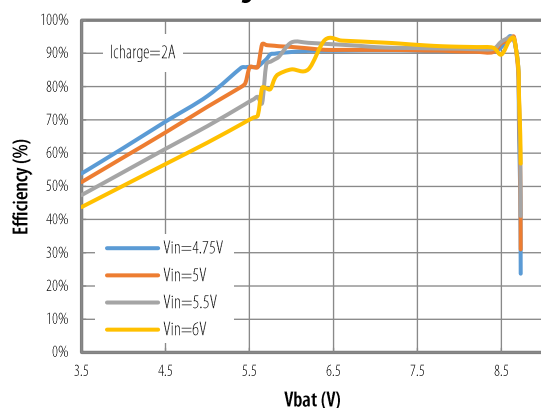
| PIN # | NAME    | DESCRIPTION   |
|-------|---------|---|
| 1     | PGND    | Power Ground pin  |
| 2,3   | SW      | Switching Pin. Connect with an inductor between this pin and VIN  |
| 4     | BST     | Bootstrap capacitor connection for the high-side FET gate driver. Connect a 10nF ceramic capacitor (voltage rating $\geq 10V$ ) from BOOT pin to SW pin.  |
| 5     | STATS   | Status pin for Boost charging. Internally pulled low when charge in progress. It becomes high impedance when charging is done.  |
| 6     | VTERM   | Charge termination voltage ( $V_{TERM}$ ) configuration pin. There is an internal pull up current 10 $\mu A$ . Connect a resistor ( $R_{VTERM}$ ) from $V_{TERM}$ pin to GROUND to set battery regulation voltage.<br>$V_{TERM}=8.4V+3*R_{VTERM}*10\mu A$ |
| 7     | ISET    | Boost Fast Charging current setting pin. Connect a resistor between this pin and analog ground to set the current level.  |
| 8     | VHOLD   | Input Dynamic Power Setting Pin. Connect VHOLD pin to a middle point of a resistor network from VIN to GND. When VHOLD voltage fall to 1.1V, charger reduces charge current.  |
| 9     | ILIMIN  | Input Current limit configuration pin. Connect a resistor to ground to set input current limit.   |
| 10    | NTC     | Thermistor Input Pin. Connect to the battery thermistor sensing network.  |
| 11    | BUCK_EN | Buck mode enable pin when ENB=0. Internal pull to GND by 2.3Mohm Resistor, Pull this pin high to enable a "BUCK"OTG mode. Float or pull to GND to enable charger  |
| 12    | ENB     | Chip disable pin. Internal pull to GND by 2.3Mohm Resistor. Connect ENB to a Logic High to disable IC   |
| 13    | VIN     | Input Power pin. Bypass with a 22 $\mu F$ capacitor from this pin to ground.  |
| 14    | AGND    | Analog Ground pin. Short to PGND as guided in PCB layout guide  |
| 15    | VLDO    | 5V Linear regulator output pin. Bypass with 1 $\mu F$ capacitor from this pin to ground   |
| 16    | BATGD   | Battery status indication pin. Low when Battery voltage is less than 6V, High when Battery voltage is greater than 6V even ENB is high level  |
| 17,18 | VBAT    | Battery Positive terminal. Connect a 22 $\mu F$ to Ground   |

| PIN # | NAME | DESCRIPTION   |
|-------|------|---|
| 19    | PMID | Midpoint of the Boost output and current limit switch. Connect a 22 $\mu$ F to Ground.<br>Do not overload or short this pin |
| 20    | PGND | Power Ground pin  |

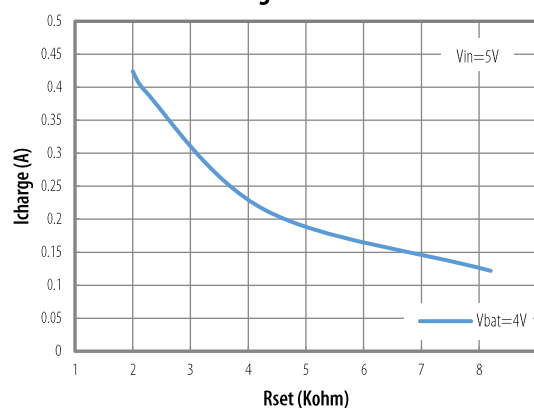
## TYPICAL CHARACTERISTICS

( $V_{in}=5V$ ,  $T_A=25^{\circ}C$ , unless otherwise specified)

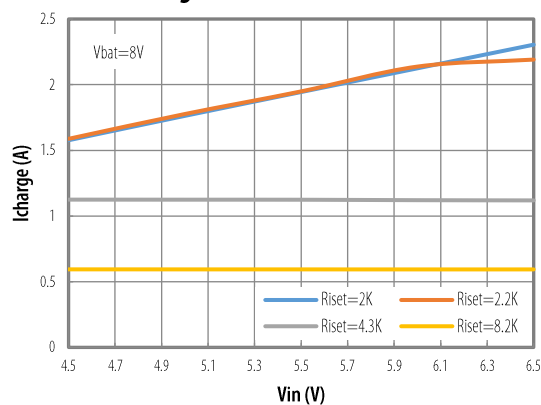
Charger Eff. Vs. Vbat



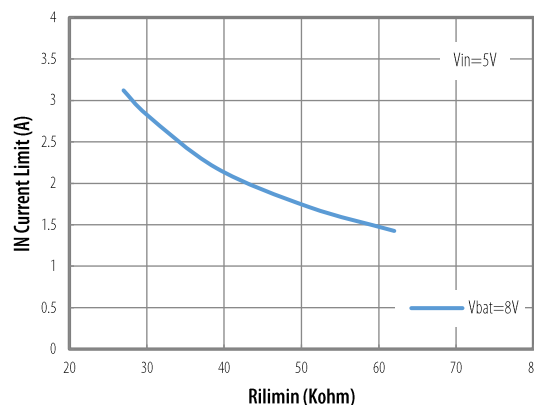
Trickle Charge Current Vs. Riset



Fast Charge Current Vs. Vin w. 3A IN Limit

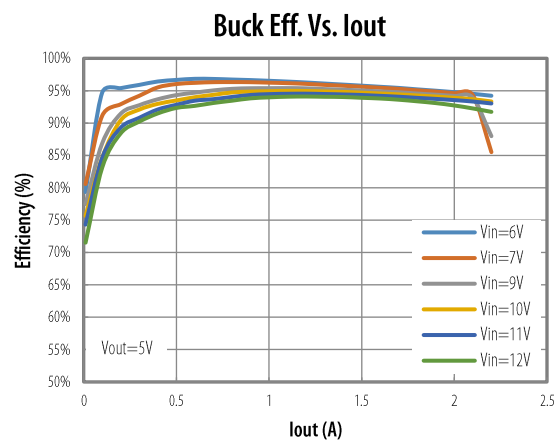
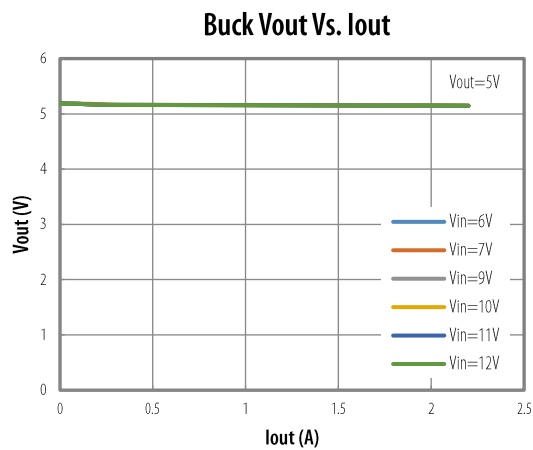
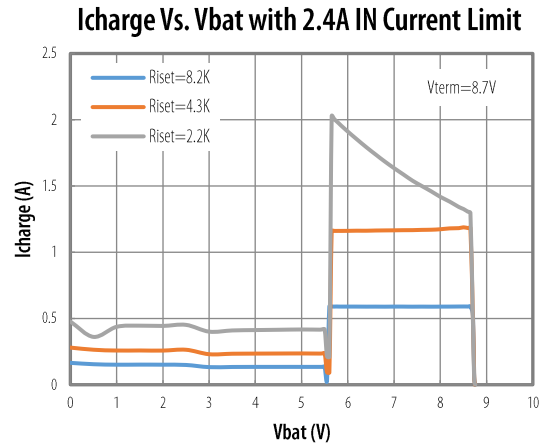
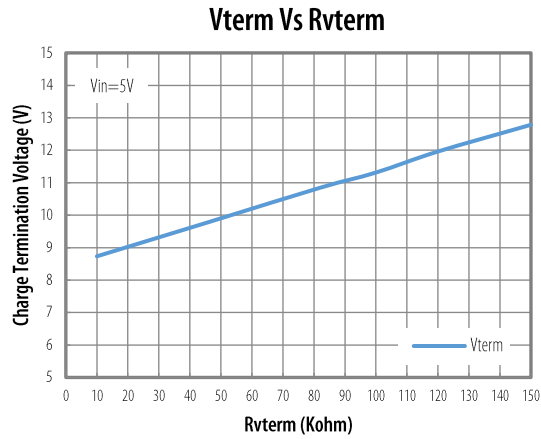


IN Current Limit Vs. Rilimin



## TYPICAL CHARACTERISTICS cont'

( $V_{in}=5V$ ,  $T_A=25^{\circ}C$ , unless otherwise specified)



## APPLICATION INFORMATION

### Setting Charge Termination Voltage

Charge termination voltage can be programmed externally in a small range by connecting a resistor from VTERM pin to ground. There is an internal 10uA pull-up current. The charge termination voltage is calculated by the following equation:

$$V_{TERM} = 8.4V + 3 \times R_{VTERM} \times 10\mu A$$

## Setting Fast Charging Current

Fast charge current can be programmed externally by connecting a resistor from ISET pin to ground. Please see below equation for Icharge setting:

$$R_{ISET} = \frac{1.1 \times 3900}{I_{CHARGE}}$$

| Charge current (A) | R <sub>ISET</sub> (Kohm) |
|--------------------|--------------------------|
| 0.5                | 8.66                     |
| 1                  | 4.32                     |
| 1.5                | 2.87                     |
| 2                  | 2.10                     |
| 2.5                | 1.69                     |

## Setting Input Current limit

The input current of the HM4049 can be programmed externally by connecting a resistor from ILINMIN pin to ground. This is for the user to configure a limit so that the front-end adapter or charging device is not overloaded. The Input current limit is calculated by the following equation:

$$I_{ILIMIN} = \frac{1.1 \times 70500}{R_{ILIMIN}}$$

| Input current limit (A) | R <sub>ILIMIN</sub> (Kohm) |
|-------------------------|----------------------------|
| 0.5                     | 154                        |
| 1                       | 76.8                       |
| 1.5                     | 51.1                       |
| 2                       | 38.3                       |
| 2.5                     | 30.9                       |

## Setting Input Dynamic Power Range, DPM, VHOLD

Then input of the HM4049 can be furthered protected by an input dynamic power setting, i.e. DPM function. When an input source current limit is unknown, this setting can help to prevent overloaded the input source by reducing charge current when the input voltage drops to a preset voltage. This preset voltage can be set by connected a resistor ladder from VIN to VHOLD to GND. The threshold of the VHOLD is 1.1V.

## OTG BUCK Mode

HM4049 also comes with an OTG BUCK feature that it can be configured to deliver power from the battery pack to VIN, by utilizing the same inductor that is used for charging. To turn on this buck mode, pull BUCK\_EN high, HM4049 enables the buck operation that steps the two cells battery voltage down to 5V at VIN. This is particular useful for power bank applications.

## STATS Indication

A STATS pin can be used to drive an indication LED to indicate charging status. In normal charging mode, it is pulled down; otherwise, it is floating.

## Setting Thermistor, NTC

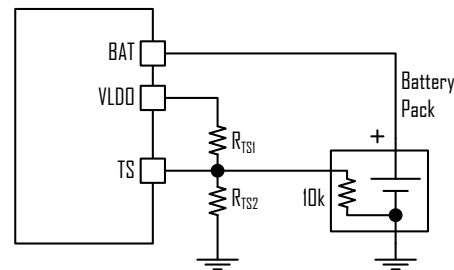
The HM4049 has a built-in NTC resistance window comparator, which allows HM4049 to monitor the battery temperature via the battery integrated thermistor. Connect an appropriate resistor from VLDO to the NTC pin and connect the thermistor from the NTC pin to GND. The resistor divider determines the NTC voltage depending on the battery temperature. If the NTC voltage falls outside of the NTC window, the HM4049 stops charging or discharging. The charger will then restart if the temperature goes back into NTC window range.

To disable the NTC function, connect 1k0mm resistor from NTC to VLDO

Following picture shows that an internal resistor divider sets the low temperature threshold ( $V_{TL}$ ) and high temperature threshold ( $V_{TH}$ ) at  $75\% \times VLDO$  and  $25\% \times VLDO$ , respectively. For a given NTC thermistor, select an appropriate  $R_{TS1}$  and  $R_{TS2}$  to set the NTC window.

$$\frac{V_{TL}}{V_{LDO}} = \frac{R_{TS2} \parallel R_{NTC\_COLD}}{R_{TS1} + R_{TS2} \parallel R_{NTC\_COLD}} = TL = 0.75$$

$$\frac{V_{TH}}{V_{LDO}} = \frac{R_{TS2} \parallel R_{NTC\_HOT}}{R_{TS1} + R_{TS2} \parallel R_{NTC\_HOT}} = TH = 0.25$$



Where  $R_{NTC\_HOT}$  is the value of the NTC resistor at the upper bound of its operating temperature range, and  $R_{NTC\_COLD}$  is its lower bound. The two resistors,  $R_{TS1}$  and  $R_{TS2}$ , independently determine the upper and lower temperature limits. This flexibility allows the HM4049 to operate with most NTC resistors for different temperature range requirements. Calculate  $R_{TS1}$  and  $R_{TS2}$  as follows:

$$R_{TS1} = \frac{R_{NTC\_HOT} \times R_{NT} \times (TL - TH)}{TH \times TL \times (R_{NTC\_COLD} - R_{NTC\_HOT})}$$

$$R_{TS2} = \frac{R_{NTC\_HOT} \times R_{NTC\_COLD} \times (TL - TH)}{TH \times (1 - TL) \times R_{NTC\_COLD} - TL \times (1 - TH) \times R_{NTC\_HOT}}$$

## BATGD indication

A BATGD pin can be used to drive an indication LED to indicate battery voltage level. In both charge and discharge mode, BATGD is pulled low when battery voltage  $< 6V$ .

## VIN > VBAT operation

In some occasions, the battery pack could be deeply discharged due to idle for a long period of time. So, the battery voltage can be quite low, sometimes even lower than the input voltage. In these occasions, upon plugging in the input, the HM4049 enters a deeply discharged battery mode, unlike a regular boost converter that cannot maintain regulation when  $V_{IN}$  is greater than  $V_{BAT}$ , HM4049 would regulate the charging current through the PMID to VBAT MOSFET providing a safer operation.

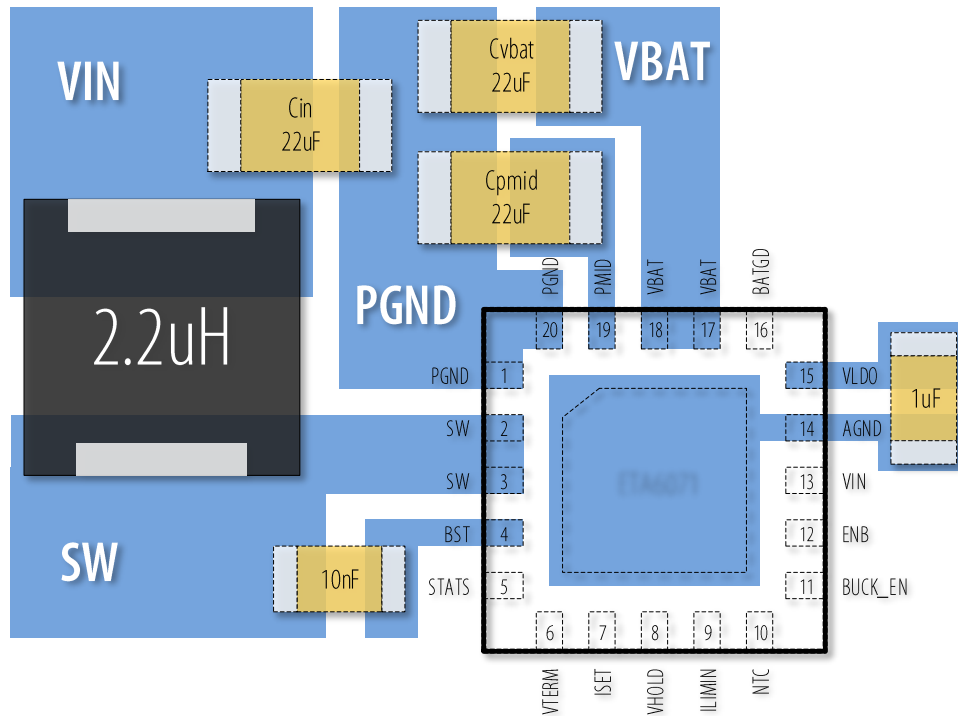
## Battery balancing

For batteries operate in series, it is imperative that the two cells are balanced to extend battery life. ETA provides a switching balance solution ETA3000 to achieve this. Please consult ETA3000 datasheet for detail.



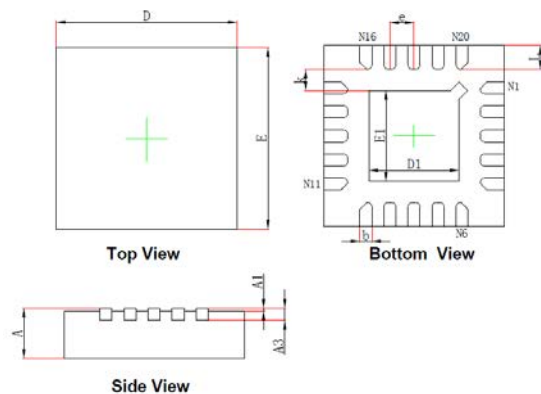
## PCB GUIDELINES

Please try to place the Cvbat, inductor, Cpmid and Cin as suggested by the illustration below. The Cvbat and Cpmid have to be placed just next to the chip with shortest wire to the VBAT and PMID pins.



## PACKAGE OUTLINE

Package: QFN3x3-20



| Symbol | Dimensions In Millimeters |             | Dimensions In Inches |             |
|--------|---------------------------|-------------|----------------------|-------------|
|        | Min.                      | Max.        | Min.                 | Max.        |
| A      | 0.700/0.800               | 0.800/0.900 | 0.028/0.031          | 0.031/0.035 |
| A1     | 0.000                     | 0.050       | 0.000                | 0.002       |
| A3     | 0.203REF.                 |             | 0.008REF.            |             |
| D      | 2.924                     | 3.076       | 0.115                | 0.121       |
| E      | 2.924                     | 3.076       | 0.115                | 0.121       |
| D1     | 1.400                     | 1.600       | 0.055                | 0.063       |
| E1     | 1.400                     | 1.600       | 0.055                | 0.063       |
| k      | 0.200MIN.                 |             | 0.008MIN.            |             |
| b      | 0.150                     | 0.250       | 0.006                | 0.010       |
| e      | 0.400TYP.                 |             | 0.016TYP.            |             |
| L      | 0.324                     | 0.476       | 0.013                | 0.019       |