# 2A Synchronous Buck Li-ion Charger

## General Description

The LP28301 is a 5A Li-Ion battery charger intended for 4.4V~14V wall adapters. It utilizes a high efficiency synchronous buck converter topology to reduce power dissipation during charging. The LP28301 includes complete charge termination circuitry, automatic recharge and a ±1% 4.2V/4.3V /4.35V float voltage.

When the adapter`s current capacity is less than the set charge current, the LP28301 would decrease the charge current automatically to keep the output of adapter would not be pull down by the chip.

Additional features include shorted cell detection; temperature qualified charging and overvoltage protection. The LP28301 is available in a low profile QFN-28 package.

## Order Information

LP28301 □ □ □

- F: Pb-Free
- Package Type
  - QV: QFN-28

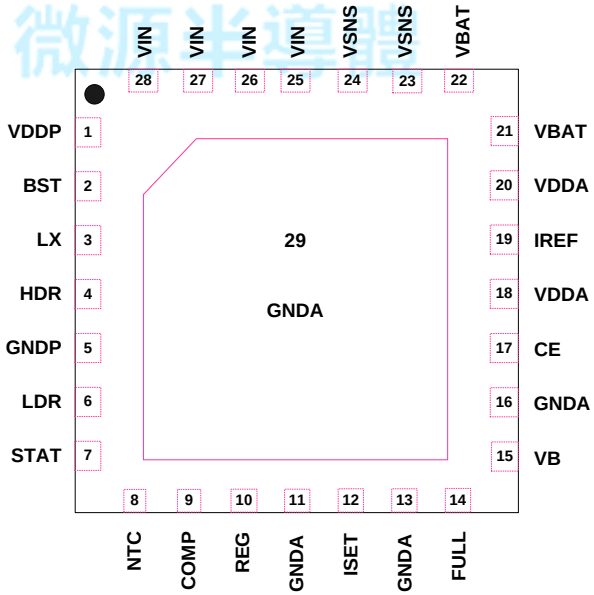
## Applications

- ✧ Quick charge 2.0/3.0 (QC2.0 / QC3.0)
- ✧ Quick charge for cell phone
- ✧ Portable Media Players
- ✧ Cellular and Smart mobile phone
- ✧ PDA/DSC
- ✧ Handheld Battery-Powered Devices
- ✧ Handheld Computers
- ✧ Charging Docks and Cradles

## Features

- ◆ Adapter Adaptive
- ◆ 5A Maximum Charge Current
- ◆ Input voltage: 4.4V~14V
- ◆ Programmable charge complete voltage: 4.2V /4.3V /4.35V
- ◆ Efficiency up to 90%
- ◆ Very Low Power Dissipation
- ◆ Operation with Thermal Regulation to Maximize Charge Rate Without Risk of Overheating
- ◆ Charges Single Cell Li-Ion Batteries Directly from USB Port
- ◆ Available in QFN28(4*4mm) Package
- ◆ RoHS Compliant and 100% Lead (Pb)-Free

## Functional Pin Description



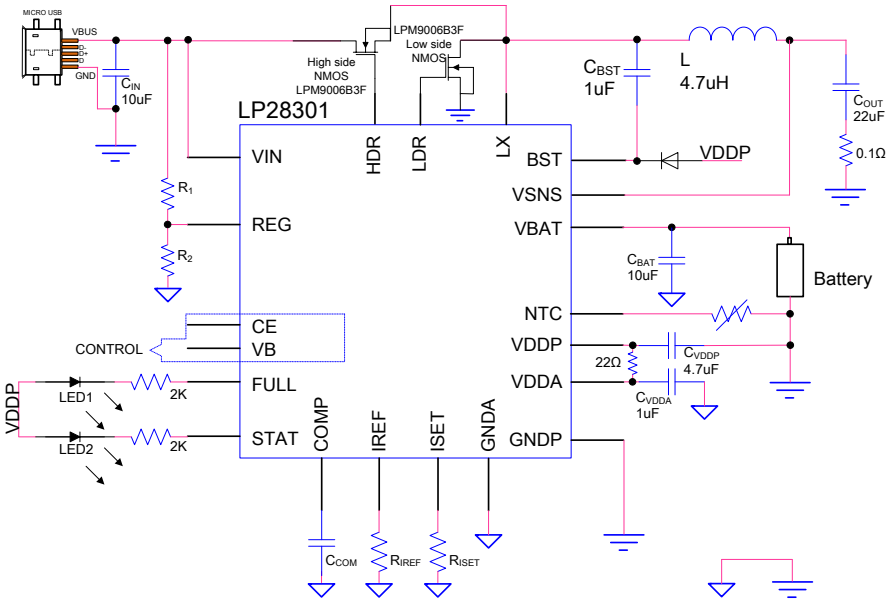

## Marking Information

| Device | Marking | Package | Shipping |
|---|---|---|---|
| LP28301QVF | LPS<br>LP28301<br>YWX | QFN-28 | 3K/REEL |
| Y: Year code. W: Week code. X: Batch numbers. | | | |

## Pin Description

| Pin | Name | Description |
|---|---|---|
| 1 | VDDP | Internal LDO output. Connect a decoupling 4.7μF capacitor to GNDP. |
| 2 | BST | Positive supply for the high side driver. A 1μF capacitor should be placed between BST and LX. |
| 3 | LX | Switching Node Connection. |
| 4 | HDR | High side drive gate. |
| 5 | GNDP | Ground for Power section. |
| 6 | LDR | Low side drive gate. |
| 7 | STAT | Indicates charge status. Active low when charging is on. STAT will blink with timeout, NTC fault. |
| 8 | NTC | Connect a 10K NTC resistor to GNDA, 100μA(constant current source) current output from NTC pin. |
| 9 | COMP | Compensation pin, a 2.2nF ceramic capacitor is needed from COMP to GNDA. |
| 10 | REG | Input voltage feedback for the input voltage regulation loop. Connect to tap of an external resistor divider from VIN to GNDA to program the input voltage regulation. Once the voltage at REG pin drops to the inner threshold, the charge current is reduced to maintain the input voltage at the regulation value. |
| 12 | ISET | Charging current setting pin, a resistor $R_{ISET}$ is needed from ISET to GNDA. CC current is programmed by $I_{BAT}=1000\times1.5V/R_{ISET}$. The internal reference for ISET comparator is 1.5V when $V_{BAT}>V_{TRIKL}$. Recommend: 6.8K > $R_{ISET}$≥0. 3K. |
| 11,13,16,29 | GNDA | Ground for the analog circuits. |
| 14 | FULL | Battery full indication pin, active low. |
| 15 | VB | Programmable battery-full voltage. Connect to GND for 4.35V, leave floating to 4.2V, and connect to VDDA for 4.3V. |
| 17 | CE | Charge enable pin. Active high. |
| 19 | IREF | Current reference generator. A 100k resistor connect to GNDA, internal voltage reference is 1V. |
| 18,20 | VDDA | Power supply for the internal analog circuit. |
| 21,22 | VBAT | Battery charger output and battery voltage sense pin. Connect to battery cell. |
| 23,24 | VSNS | Connect the internal sense resistor to protect the battery. |
| 25,2627,28 | VIN | USB or adapter input. |

## Typical Application Circuit




## Absolute Maximum Ratings Note 1

- ✧ Input to GND(VIN) ---------- -0.3V to 18V
- ✧ Other Pin to GND ---------- -0.3V to 6.5V
- ✧ LX voltage to GND ---------- -0.3V to 18V
- ✧ HDR,BST voltage to GND ---------- -0.3V to 23V
- ✧ BST referred to LX ---------- -0.3V to 6.5V
- ✧ BAT Short-circuit Duration ---------- Continuous
- ✧ Maximum Junction Temperature ---------- 150℃
- ✧ Storage Temperature ---------- -45℃ to 165℃
- ✧ Operating Ambient Temperature Range ($T_A$) ---------- -40℃ to 85℃
- ✧ 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 (QFN-28, $P_D$, $T_A$=25℃) ---------- 2W
- ✧ Thermal Resistance (QFN-28, $\theta_{JA}$) ---------- 50℃/W

## ESD Susceptibility

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

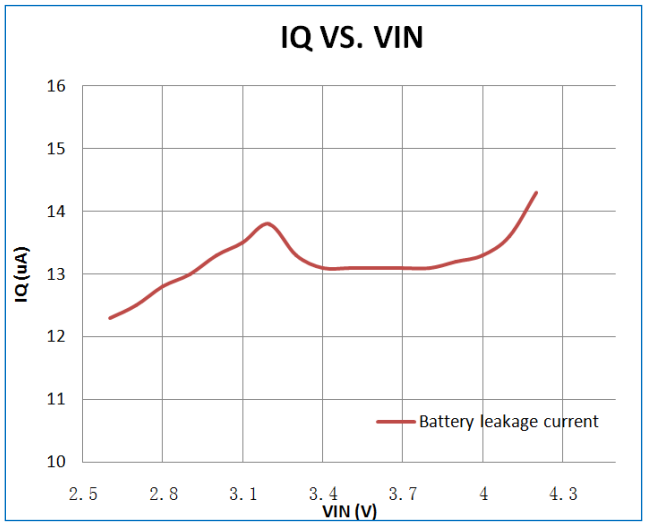
## Electrical Characteristics

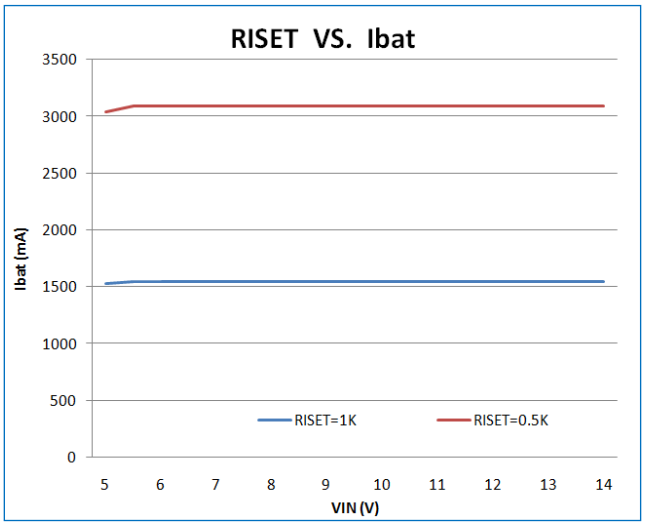
(The specifications which apply over the full operating temperature range, otherwise specifications are at $T_A$=25℃, $V_{IN}$ = 5V, unless otherwise noted.)

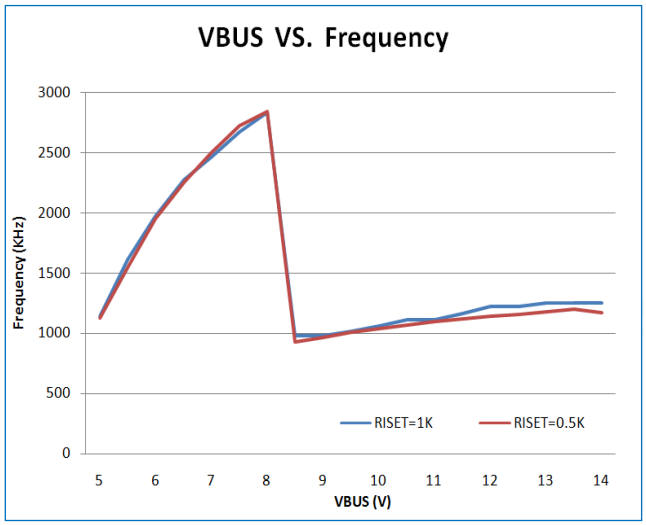
| Parameter | Test Conditions | Measured | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **VIN** | | | | | | |
| Input Voltage | | $V_{IN}$ | 4.4 | | 14 | V |
| VIN Port Protection Threshold | $V_{IN}$ Rising | UVLO | 4.15 | 4.25 | 4.35 | V |
| | $V_{IN}$ Falling | | 3.95 | 4.05 | 4.15 | V |
| Input Voltage Regulation Reference | | $V_{REG}$ | 2.3 | 2.4 | 2.5 | V |
| VDDP/VDDA Voltage | | | | 5 | | V |
| Switch between VSNS and VBAT | $V_{BAT}$=4.2V, $V_{IN}$ Absent, $I_{BAT}$=3A | $R_{(VSNS,VBAT)}$ | | 40 | | mΩ |
| **QUIESCENT CURRENTS** | | | | | | |
| VIN Current | $V_{IN}$=4V | $I_{IN}$ | | 80 | | μA |
| Battery Discharge Current in STANDBY MODE | $V_{BAT}$=4.2V | $I_{BAT}$ | | 15 | | μA |
| **Charger Controller** | | | | | | |
| Trickle Charge Condition | $V_{BAT}$<1.4V | $V_{ISET}$ | | 0.04 | | V |
| | 1.4V<$V_{BAT}$<$V_{TRICKL}$ | | | 0.2 | | V |
| VBAT voltage | VB=float, $R_{ISET}$=1K,$I_{BAT}$=100mA | | 4.158 | 4.2 | 4.242 | V |
| | VB=high, $R_{ISET}$ =1K, $I_{BAT}$=100mA | | | 4.3 | | V |
| | VB=low, $R_{ISET}$=1K, $I_{BAT}$=100mA | | | 4.35 | | V |
| Charge Current in CC Mode | $R_{ISET}$=1K,$V_{BAT}$=3.6V | $I_{BAT}$ | | 1500 | | mA |
| | $R_{ISET}$=0.5K,$V_{BAT}$=3.6V | | | 3000 | | mA |
| Current Mode (CC) | | $V_{ISET}$ | 1.45 | 1.5 | 1.55 | V |
| Trickle Charge Voltage Threshold | $V_{BAT}$ rising | $V_{TRIKL}$ | 2.8 | 2.9 | 3.0 | V |
| Trickle Charge Voltage Threshold Hysteresis | | $V_{TRIKL\_HYS}$ | | 200 | | mV |
| Charge Current in Trickle Charge Condition | $V_{BAT}$ < 1.4V | $I_{TRIKL}$ | | 15 | | mA |
| | 1.4V < $V_{BAT}$ < $V_{TRIKL}$, $R_{ISET}$=1K | | | 200 | | mA |
| | 1.4V < $V_{BAT}$ < $V_{TRIKL}$, $R_{ISET}$=0.5K | | | 400 | | mA |
| End of Charger Current | | | | 13.3 | | %$I_{CC}$ |
| Switch Frequency | $V_{IN}$=5V,$V_{BAT}$=3.6V,$R_{ISET}$=0.5K | | | 1.2 | | MHz |
| Trickle Charge Timer | Default register, wake-up mode | | | 90 | | min |
| Charge Timer | Default register, CC+CV mode | | | 10 | | h |
| Recharge Threshold | $V_{BAT}$ falling | | | 150 | | mV |
| STAT Low Level | Open drain pulled up with 5mA | STAT | | | 0.2 | V |
| Leakage Current to STAT | $V_{BAT}$=4.3V, $I_{BAT}$=0 | | | 0.6 | 1 | μA |
| FULL Low Level | Open drain pulled up with 5mA | FULL | | | 0.2 | V |
| Leakage Current to FULL | $V_{BAT}$=4.3V, $I_{BAT}$=0 | | | 0.6 | 1 | μA |
| CE Threshold | Enable charge, CE rising | $V_{CER}$ | 3.5 | | | V |
| | Disable charge, CE falling | $V_{CEF}$ | | | 2 | V |
| **Temperature sense comparators** | | | | | | |
| High Voltage Threshold | Temp fault at $V_{NTC}$>$V_{LTF}$ | $V_{LTF}$ | 2.45 | 2.500 | 2.55 | V |
| Low Voltage Threshold | Temp fault at $V_{NTC}$<$V_{HTF}$ | $V_{HTF}$ | 0.48 | 0.500 | 0.52 | V |
| Temperature sense current sense | $R_{NTC}$=10k | $I_{NTC}$ | 94 | 100 | 106 | μA |
| Charging Temperature Shutdown | Temperature rising | | | 145 | | ℃ |
| | Hysteresis falling | | | 25 | | ℃ |

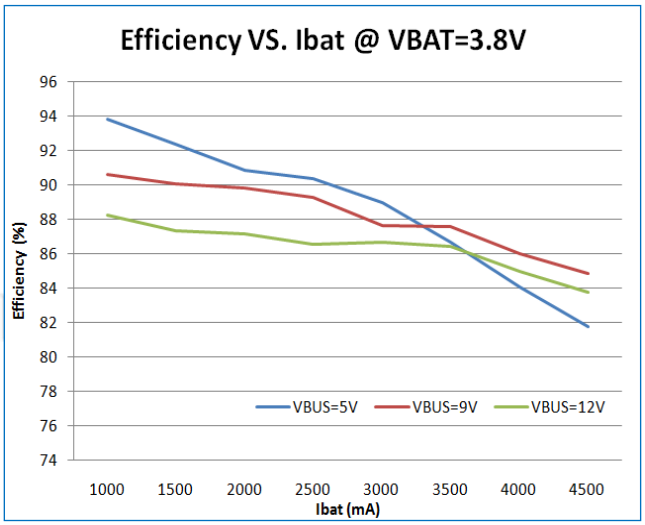
## Typical Operating Characteristics

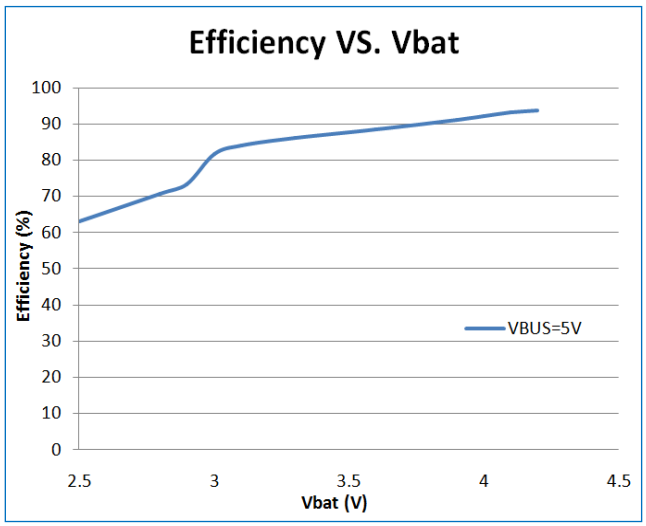
($T_A$=25℃，unless otherwise noted)

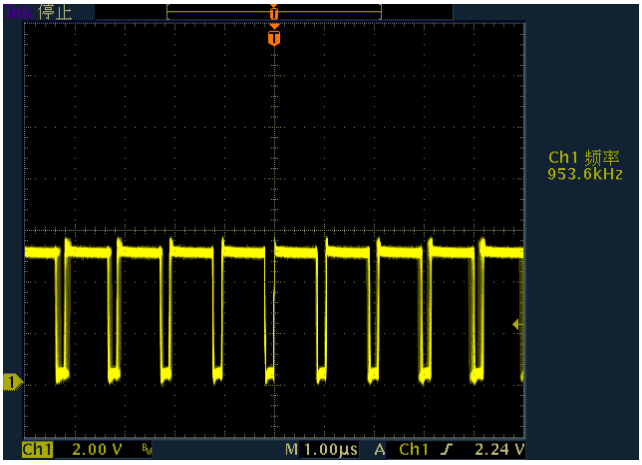


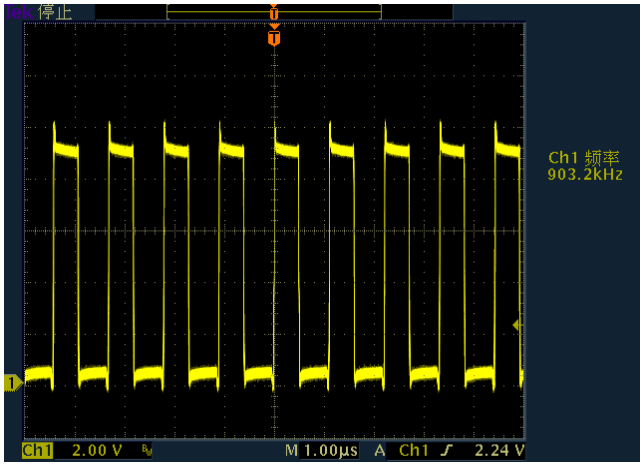



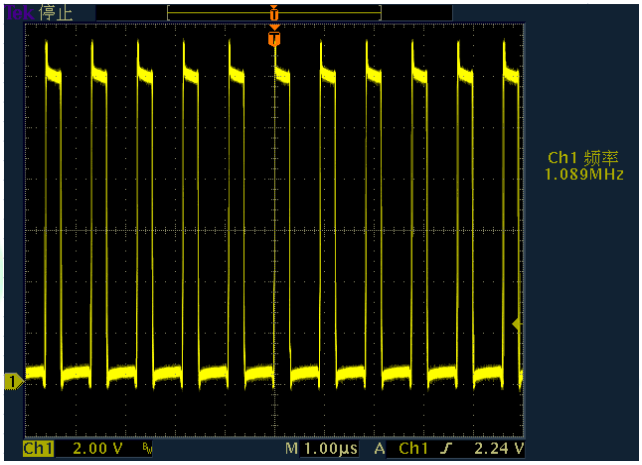






Charge waveform: $I_{BAT}$=3A, $V_{BUS}$=5V




Charge waveform: $I_{BAT}$=3A, $V_{BUS}$=9V




Charge waveform: $I_{BAT}$=3A, $V_{BUS}$=12V

## Application Information

The LP28301 is a single cell Li-Ion battery charger. It integrates the input reverse-blocking FET, high-side switching FET, low-side switching FET, and BATFET between $V_{SNS}$ and battery to protect battery. The device also integrates the bootstrap diode for the high-side gate drive.

### Power Up from DC Source

When the DC source plugs in, the LP28301 checks the input source voltage to turn on REGN LDO and all the bias circuits. It also checks the input current limit before starts the buck converter.

### Input Source Qualification

After REGN LDO powers up, the LP28301 checks the current capability of the input source. The input source has to meet the following requirements to start the buck converter.

1. VIN voltage below 14V

2. REG voltage above 2.43V

Once the input source passes all the conditions above, then a permit signal is asserted to the chip.

### Adapter Current Detection

The USB ports on personal computers are convenient charging source for portable devices (PDs). If the portable device is attached to a USB host, the USB specification requires the portable device to draw limited current (100mA/500mA in USB 2.0, and 150mA/900mA in USB 3.0). If the portable device is attached to a charging port, it is allowed to draw up to the maximum current form the USB host by VREG voltage above 2.43V.

### Charge state indication

As showed below, the STAT and FULL LED respond to this six STATES.

| STATE | STAT | FULL |
|---|---|---|
| Without Battery | Flicker | Light On |
| Charging | Light On | Light Off |
| Charge Complete | Light Off | Light On |
| Battery Overheat | Flicker | Light Off |
| Time Out | Flicker | Light Off |
| $V_{REG}$ < $V_{REG}$(th) | Light On | Light Off |

### Battery Charging Management

The LP28301 charges 1-cell Li-Ion battery with up to 5A charge current for high capacity tablet battery. The low dissipation BATFET improves charging efficiency and minimizes the voltage drop during discharging.

### Autonomous Charging Cycle

With battery charging enabled, the LP28301 can complete a charging cycle.

The charger device automatically terminates the charging cycle when the charging current is below termination threshold and charge voltage is above recharge threshold. When a full battery voltage is discharged below recharge threshold 0.15V, the LP28301 automatically starts another charging cycle. The STAT output indicates the charging status of charging (LOW), charging complete or charge disable (HIGH) or charging fault (Blinking). The three states indicate the different charging phases: low-charging, high-charge complete, blink-charge fault. Another charge down indication is FULL(low when charge complete or without battery).

### Battery Charging Profile

The device charges the battery in three phases: preconditioning, constant current and constant voltage. At the beginning of a charging cycle, the device checks the battery voltage and applies current.

### Battery Temperature Detection

The LP28301 continuously monitors battery temperature by measuring the voltage between the NTC pins and ground, typically determined by a negative temperature coefficient thermistor and an external voltage divider. The device 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 $V_{LTF}$ to $V_{HTF}$ thresholds. There is a constant current source in NTC which is 100μA($I_{NTC}$) flowing out form this pin. So $V_{NTC}$ is $I_{NTC}$×$R_{NTC}$.

When the NTC fault occurs, the STAT pin will blink to indicate the fault.

### ISET ramming Charge Current

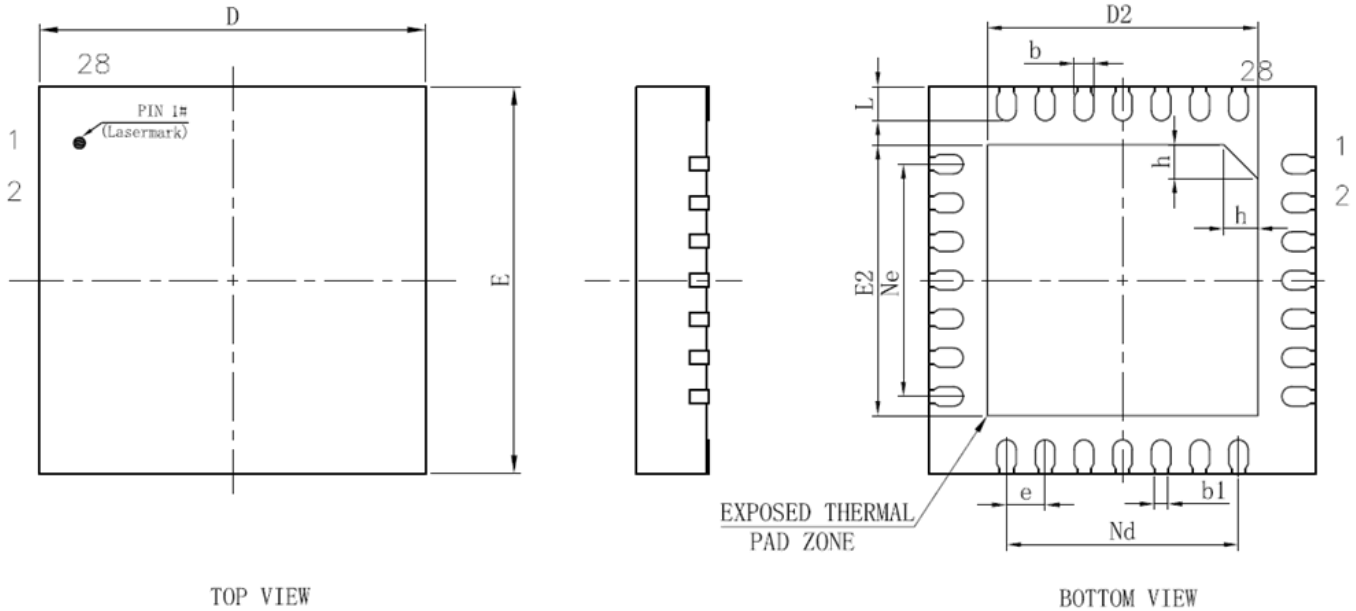
The charge current is $R_{ISET}$ rammed using a single resistor from the ISET pin to ground. The battery charge current is 1000 times the current out of the ISET pin. The $R_{ISET}$ ram resistor and the charge current are calculated using the following equations:

$$I_{CHG}(A) = 1000 \times \frac{1.5V}{R_{ISET}(\Omega)}$$

Note: $V_{ISET}$ is 1.5Volts when $V_{BAT}$>$V_{TRIKL}$.

## Packaging Information

QFN-28




| SYMBOL | MILLIMETER | | |
|---|---|---|---|
| | MIN | NOM | MAX |
| A | 0.70 | 0.75 | 0.80 |
| A1 | 0 | 0.02 | 0.05 |
| b | 0.15 | 0.20 | 0.25 |
| b1 | | 0.14REF | |
| c | 0.18 | 0.20 | 0.25 |
| D | 3.90 | 4.00 | 4.10 |
| D2 | 2.70 | 2.80 | 2.90 |
| e | | 0.40BSC | |
| Ne | | 2.40BSC | |
| Nd | | 2.40BSC | |
| E | 3.90 | 4.00 | 4.10 |
| E2 | 2.70 | 2.80 | 2.90 |
| L | 0.30 | 0.35 | 0.40 |
| h | 0.30 | 0.35 | 0.40 |