# Single and Dual Cell Li+ Battery Charger IC –LP28009

## General Description

The LP28009 is a fully integrated low cost single-cell Li-Ion battery charger IC ideal for portable applications. The LP28009 is capable of being powered up from AC adapter. The LP28009 enters sleep mode when AC adapter is removed. The LP28009 optimizes the charging task by using a control algorithm including preconditioning mode, fast charge mode and constant voltage mode. The charging task is terminated as the charge current drops below the preset threshold. The AC adapter charge current can be programmed up to 1A with an external resister. The internal thermal feedback circuitry regulates the die temperature to optimize the charge rate for all ambient temperatures. The LP28009 features 18V maximum rating voltages for AC adapter. The other features are under voltage protection, over voltage protection for AC adapter supply and battery temperature monitoring.

## Order Information

LP28009 - □ □ □ □ □

F: Pb-Free

Package Type
SP: SOP-8(EP)

Output Voltage
42: 4.2V
84: 8.4V

## Applications

- Portable Media Players/MP3 players
- Cellular and Smart mobile phone
- PDA/DSC
- Bluetooth Applications

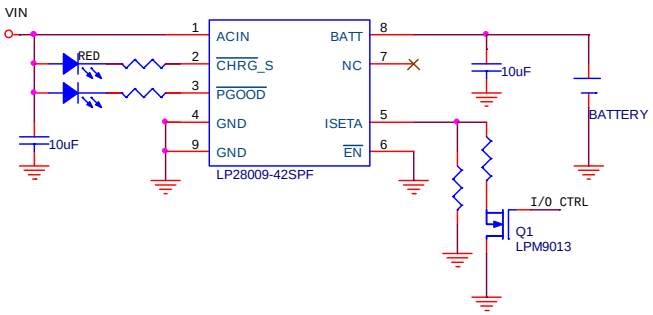
## Marking Information

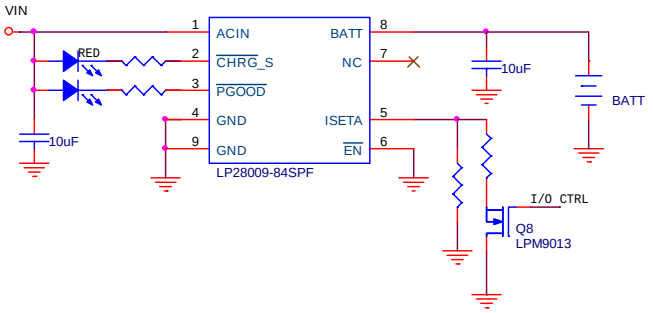
Please see website of LP28009:
www.lowpowersemi.com.

## Features

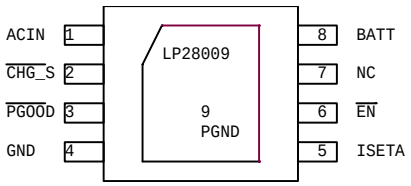
- 18V Maximum Rating for AC Adapter
- Internal Integrate P-MOSFETs
- AC Adapter Power Good Status Indicator
- Charge Status Indicator
- Under Voltage Protection
- Over Voltage Protection
- Automatic Recharge Feature
- Battery Temperature Monitoring
- Small 8-Lead SOP(EP) Package
- Thermal Feedback Optimizing Charge Rate
- ROHS Compliant and 100% Lead (Pb)-Free

## Typical Application Circuit



## Functional Pin Description

| Package Type | Pin Configurations |
|---|---|
| ESOP- 8 |  |

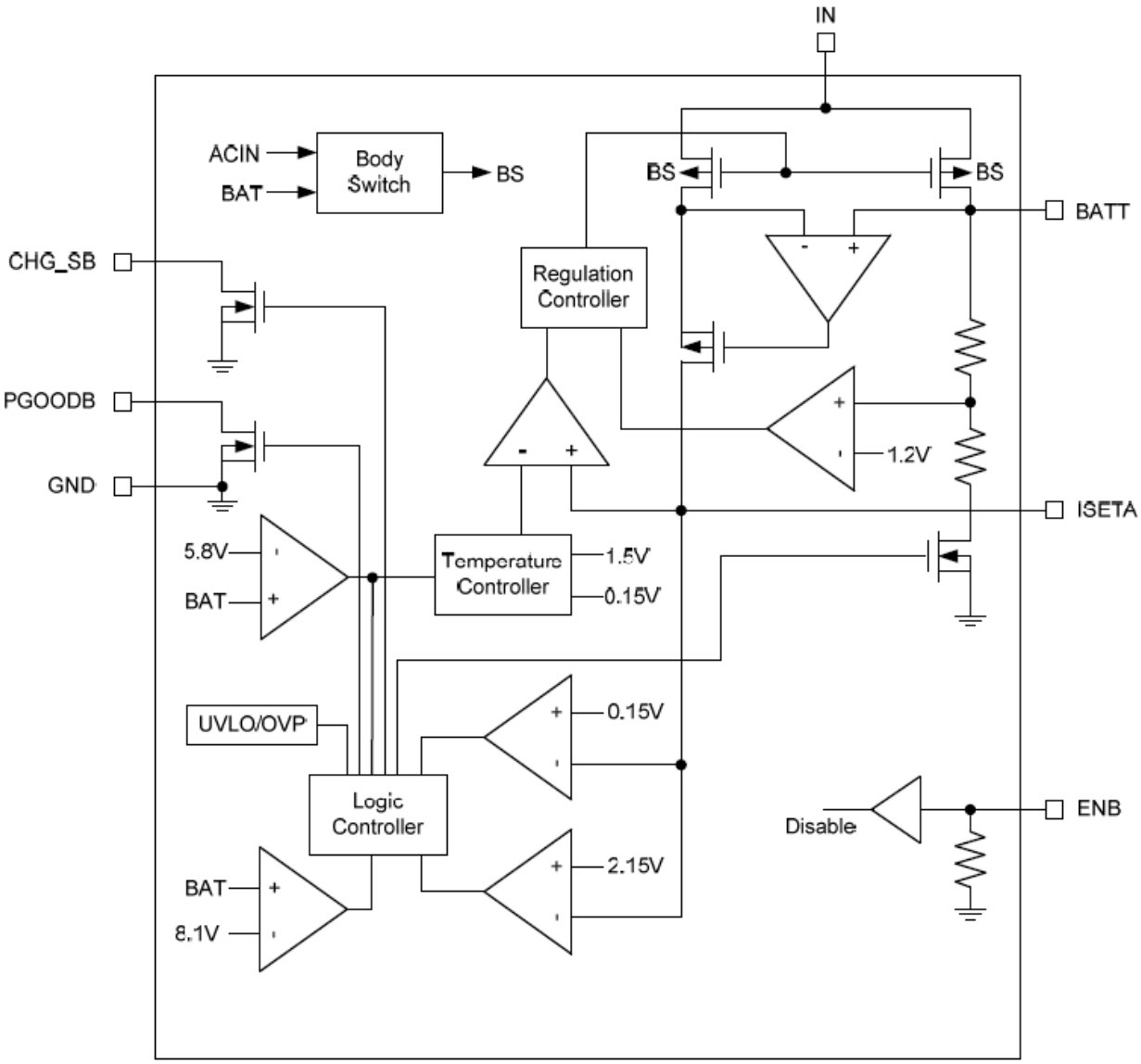


**Pin Description**

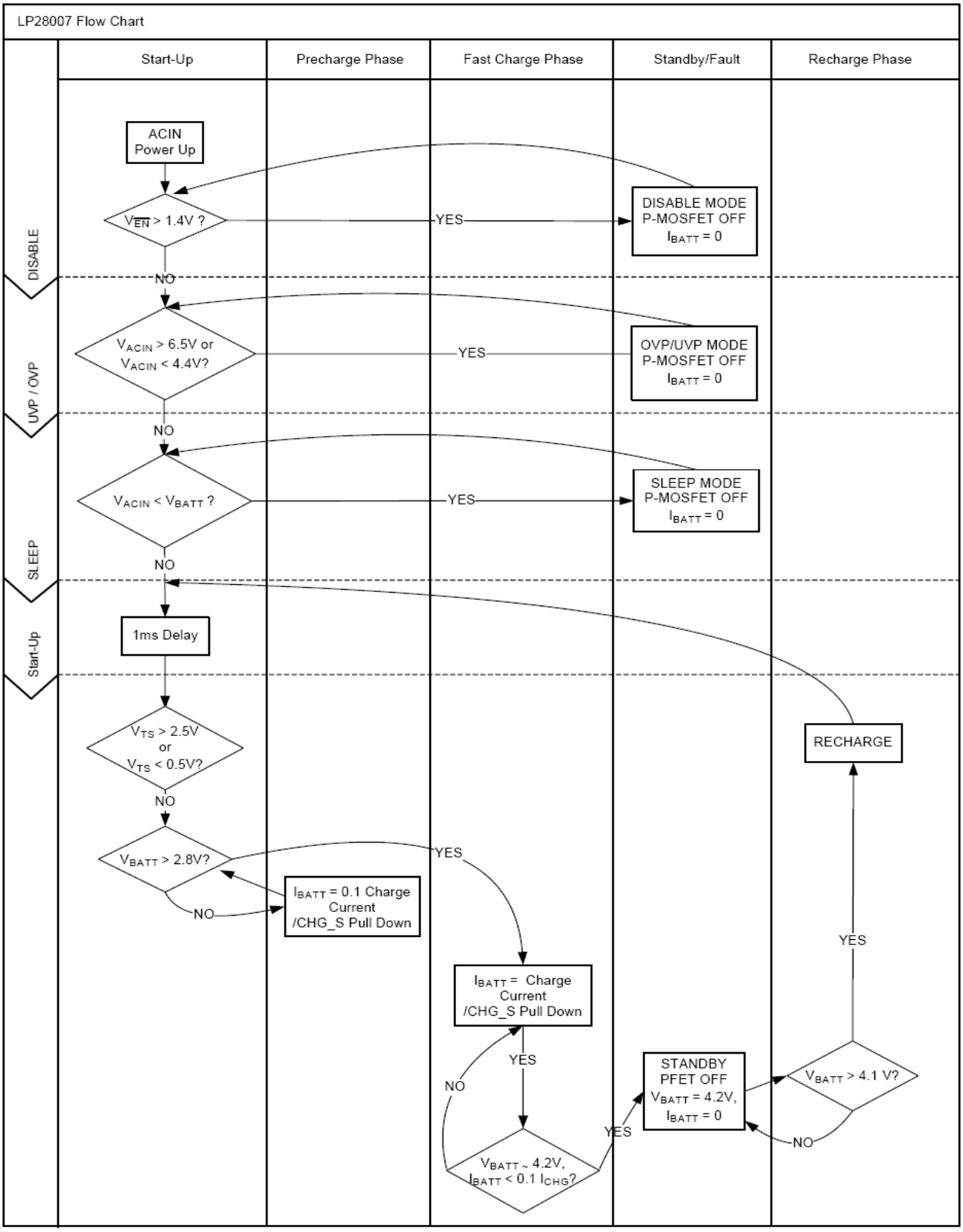
| Pin No | Pin Name | Pin Function |
|---|---|---|
| 1 | ACIN | Wall Adaptor Charge Input Supply. |
| 2 | $\overline{CHG_S}$ | Charge Status Indicator Output(Open Drain). |
| 3 | $\overline{PGOOD}$ | Power Good Indicator Output(Open drain). |
| 4 | GND | Ground. |
| 5 | ISETA | Wall Adaptor supply charge current Set point. |
| 6 | $\overline{EN}$ | Charge Enable Input(active low). |
| 7 | NC | No Internal Connection. |
| 8 | BATT | Battery Charge Current Output.<br>This pin provides charge current to the battery and regulates the final float voltage to4.2 or8.4V. An internal precision resistor divider from this pin sets the float voltage which is disconnected in shutdown mode. |
| 9(Exposed Pad) | PGND | Exposed Pad Should be soldered to PCB Board and Connected to GND. |

Note: LP28009-42SPF and LP28009-84SPF of Battery (Pin8) is output pin, the pin connector to Battery.

## Function Block Diagram



LP28009-42 Flow Chart



## Absolute Maximum Ratings (Notes 1, 2)

| | | | |
|---|---|---|---|
| $V_{IN}$, $V_{BATT}$, $V_{CHGSB}$, $V_{PROODB}$, $V_{EN}$ | -0.3V to 15V | Storage Temperature Range | -65°C to 150°C |
| $V_{ISETA}$ | -0.3V to 3.6V | Junction Temperature ($T_J$) | 150°C |
| Power Dissipation | (Note 5) | Lead Temperature (Soldering, 10 sec.) | 260°C |

## Operating Ratings (Note 1, 2)

| | | | |
|---|---|---|---|
| Supply Voltage | 9V to 13.5V | Thermal Resistance ($\theta_{JA}$ , Note 3)) | 120°C/W |
| Operating Temperature Range | -40°C to 85°C | Thermal Resistance ($\theta_{JC}$ , Note 4)) | 8.5°C/W |

## Electrical Characteristics

$T_A$ = 25°C, $V_{IN}$ = 10V; unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Input Operating Voltage Range | | 9 | 10 | 13.5 | V |
| $I_{CC}$ | Input Supply Current | Charge Mode, $R_{SET}$ = 30K (Note 6) | | 300 | | uA |
| | | Standby Mode (Charge Terminated) | | 250 | | uA |
| | | Shutdown Mode ($R_{SET}$ Not Connected, $V_{IN}$ < $V_{BATT}$ or $V_{IN}$ < $V_{UV}$) | | 190 | | uA |
| $V_{FLOAT}$ | Regulated Output (Float) Voltage | 0°C ≦ $T_A$ ≦ 85°C | 8.316 | 8.4 | 8.484 | V |
| $I_{BATT}$ | BATT Pin Current | $R_{SET}$ = 1.5K, Current Mode | | 500 | | mA |
| | | $R_{SET}$ = 0.75K, Current Mode | | 1000 | | mA |
| | | Standby Mode, $V_{BATT}$ = 8.4V | -1 | 0 | 1 | uA |
| | | Shutdown Mode | -1 | 0 | 1 | uA |
| | | Sleep Mode, $V_{IN}$ = 0V | -1 | 0 | 1 | uA |
| $I_{TRICKLE}$ | Trickle Charge Current | $V_{BATT}$ < $V_{TRICKLE}$, $R_{SET}$ = 1.5K | | 60 | | mA |
| | | $V_{BATT}$ < $V_{TRICKLE}$, $R_{SET}$ = 0.75K | | 120 | | mA |
| $V_{TRICKLE}$ | Trickle Charge Threshold Voltage | $R_{SET}$ = 1.5K, $V_{BATT}$ Rising | | 5.8 | | V |
| $V_{TRHYS}$ | Trickle Charge Hysteresis Voltage | $R_{SET}$ = 1.5K | | 250 | | mV |
| $V_{MSD}$ | Manual Shutdown Threshold Voltage | ISETA Pin Rising | | 2.15 | | V |
| | | ISETA Pin Falling | | 2.05 | | V |
| $V_{ASD}$ | $V_{IN}$-$V_{BATT}$ Lockout Threshold Voltage | $V_{IN}$ from High to Low | | 30 | | mV |
| | | $V_{IN}$ from Low to High | | 60 | | mV |
| $I_{TERM}$ | C/10 Termination Current Threshold | $R_{SET}$ = 1.5K | | 0.1 | | mA/mA |
| | | $R_{SET}$ = 0.75K | | 0.1 | | mA/mA |
| $V_{SET}$ | ISETA Pin Voltage | $R_{SET}$ = 1.5K, Current Mode | | 1.5 | | V |
| $I_{CHG_SB}$ | CHG_SB Pin Weak Pull-Down Current | $V_{CHG_SB}$ = 5.0V | | 25 | | uA |
| $V_{CHG_SB}$ | CHG_SB Pin Output Low Voltage | $I_{CHG_SB}$ = 5mA | | 0.35 | | V |
| $V_{POOGDB}$ | PGOODB Pin Output Low Voltage | $I_{PGOODB}$ = 5mA | | 0.35 | | V |

| Parameter | | Symbol | Test Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|
| **Precharge** | | | | | | | |
| BATT Pre-Charge Rising Threshold | | $V_{PRECH}$ | | 2.6 | 2.8 | 3 | V |
| BATT Pre-Charge Threshold Hysteresis | | $\Delta V_{PRECH}$ | | 50 | 100 | 200 | mV |
| Pre-Charge Current | | $I_{PCHG}$ | $V_{BATT}$ = 2V | 8 | 10 | 12 | % |
| **Recharge Threshold** | | | | | | | |
| BATT Re-Charge Falling Threshold Hysteresis | | $\Delta V_{RECH_L}$ | $V_{REG} - V_{BATT}$ | 60 | 100 | 150 | mV |
| **Charge Termination Detection** | | | | | | | |
| Termination Current Ratio (default) | | $I_{TERM}$ | $V_{BATT}$ = 4.2V | -- | 10 | -- | % |
| **Logic Input/Output** | | | | | | | |
| $\overline{CHG_S}$ Pull Down Voltage | | $V_{\overline{CHG_S}}$ | TBD, $I_{\overline{CHG_S}}$ = 5mA | -- | 65 | -- | mV |
| $\overline{PGOOD}$ Pull Down Voltage | | $V_{\overline{PGOOD}}$ | TBD, $I_{\overline{PGOOD}}$ = 5mA | -- | 220 | -- | mV |
| $\overline{EN}$ Threshold | Logic-High Voltage | $V_{IH}$ | | 1.5 | -- | -- | V |
| | Logic-Low Voltage | $V_{IL}$ | | -- | -- | 0.4 | V |
| $\overline{EN}$ Pin Input Current | | $I_{\overline{EN}}$ | $V_{\overline{EN}}$ = 2V | -- | -- | 2 | μA |
| **Protection** | | | | | | | |
| Thermal Regulation | | | | -- | 125 | -- | °C |
| OVP SET | | | Internal Default | -- | 6.5 | -- | V |

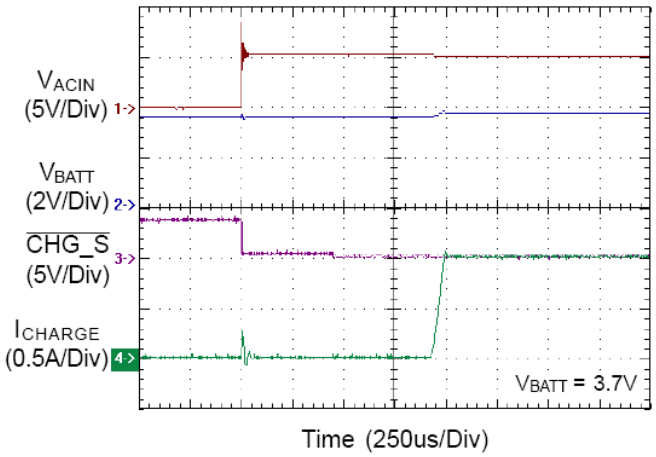
**Note 1.** Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

**Note 2.** $\theta_{JA}$ is measured in the natural convection at $T_A$ = 25°C on a high effective thermal conductivity test board (4 layers, 1S) of JEDEC 51-7 thermal measurement standard. The case point of $\theta_{JC}$ is on the expose pad for the package.

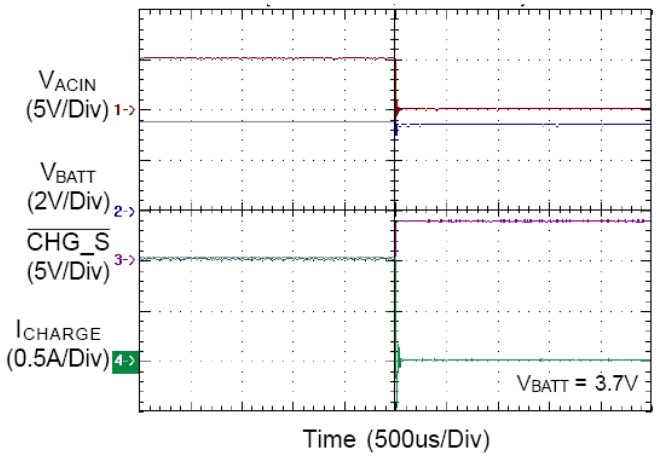
**Note 3.** Devices are ESD sensitive. Handling precaution is recommended.

**Note 4.** The device is not guaranteed to function outside its operating conditions.

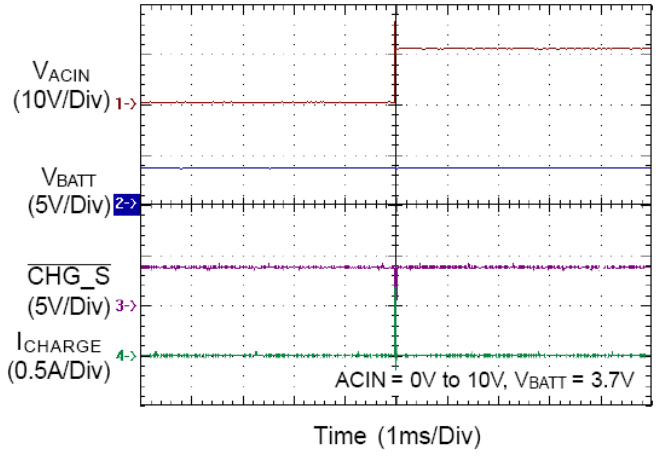
**ACIN Power On**



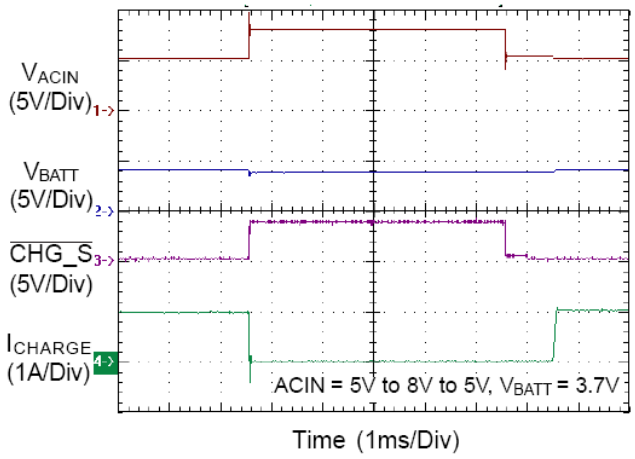

**ACIN Power Off**



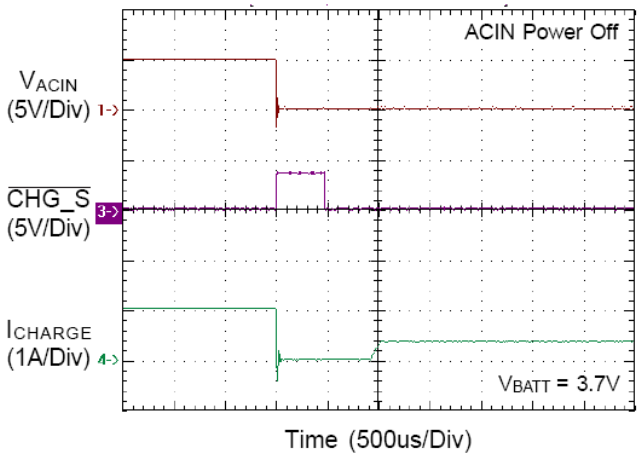

**ACIN OVP**



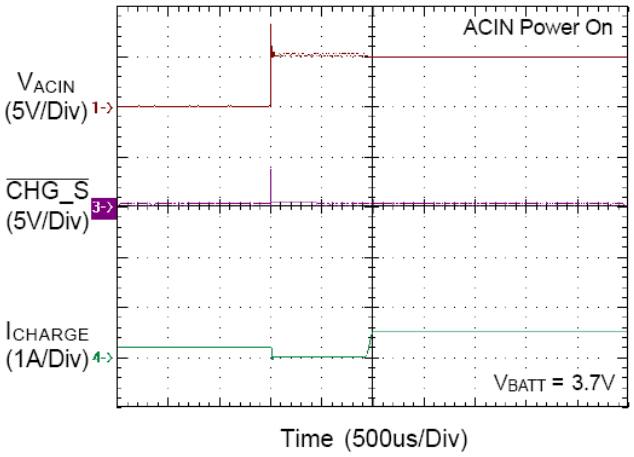

**ACIN OVP**



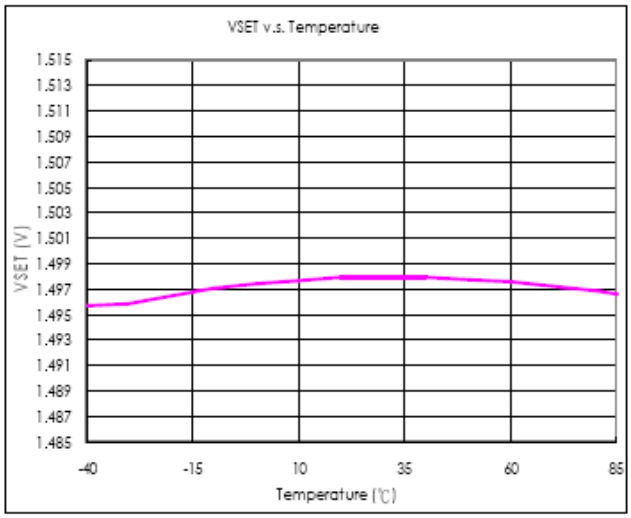

**Input Voltage Transition**



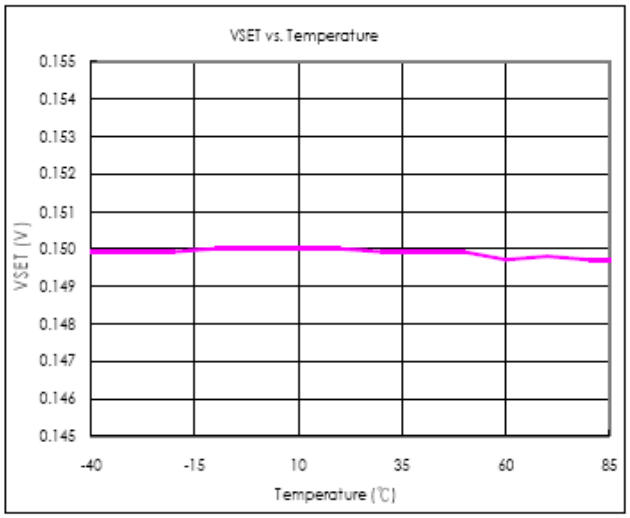

**Input Voltage Transition**



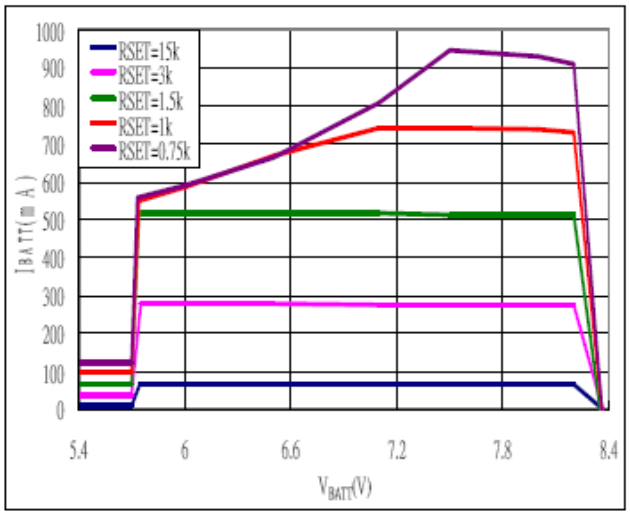
**$V_{SET}$ vs. Temperature ($V_{BATT}$ > 5.8V)**



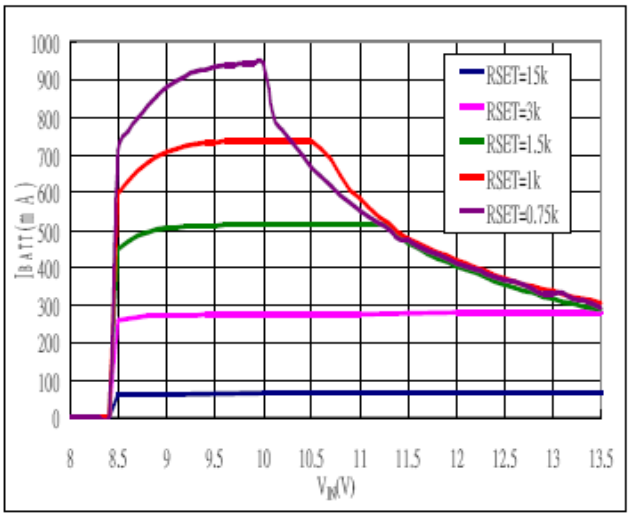

**$V_{SET}$ vs. Temperature ($V_{BATT}$ < 5.8V)**



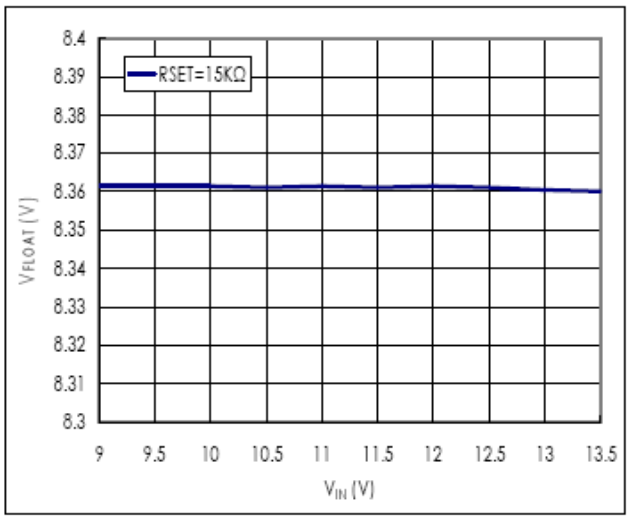

**Charge Current vs. Battery Voltage ($V_{IN}$=10V)**



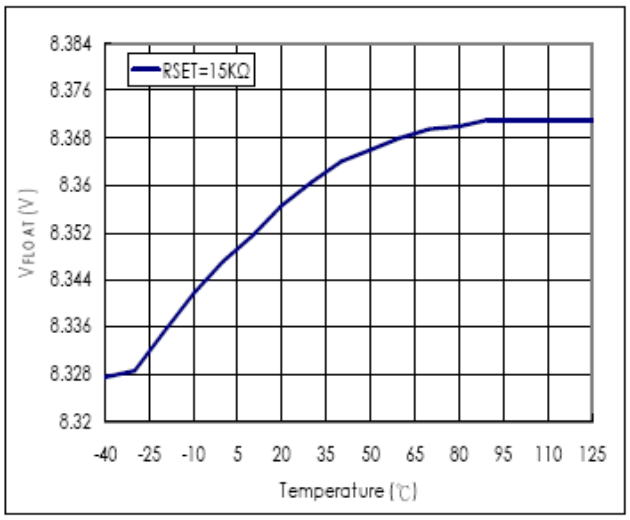

**Charge Current vs. $V_{IN}$ ($V_{BATT}$=8.0V)**




**Regulated Output Voltage vs. Supply Voltage**




**Regulated Output Voltage vs. Temperature**



## Application Information

**Automatically Power Source Selection**

The LP28009 is a battery charger IC which is designed for Li-ion Battery with 4.2V rated voltage. ACIN Mode : When the ACIN input voltage is higher than the UVP voltage level (4.4V), the LP28009 will turn on ACINP-MOSFET. Sleep Mode : The LP28009 will enter Sleep Mode when ACIN input voltage are removed. This feature provides low leakage current from the battery during the absence of input supply.

**ACIN Over Voltage Protection**

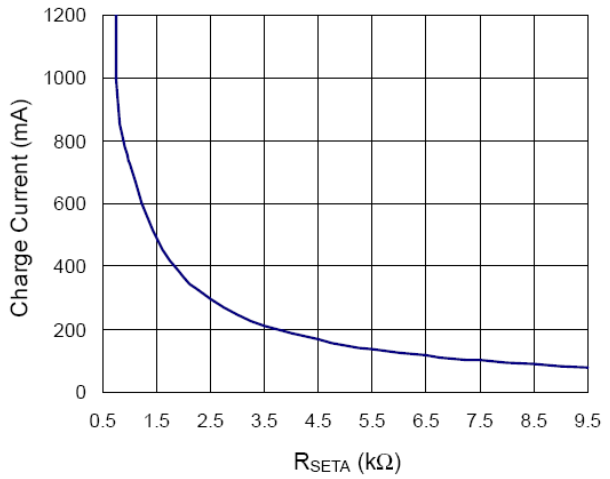
The ACIN input voltage is monitored by an internal OVP comparator. The comparator has an accurate reference of 2.5V from the band-gap reference. The OVP threshold is set by the internal resistive. The protection threshold is set to 6.5V. When the input voltage exceeds the threshold, the comparator outputs a logic signal to turn off the power P-MOSFET to prevent the high input voltage from damaging the electronics in the handheld system. When the input over voltage condition is removed (ACIN < 6V), the comparator re-enables the output by running through the soft-start.

**Fast-Charge Current Setting**

The LP28009 offers ISETA pin to determine the ACIN charge rate from 100mA to 1.2A. The charge current can be calculated as following equation.

$$I_{charge_ac} = K_{SET} \frac{V_{SET}}{R_{SETA}}$$

The parameter $K_{SET}$ = 300 ; $V_{SET}$ = 2.5V. $R_{SETA}$ is the resistor connected between the ISETA and GND.




**Pre- Charge Current Setting**

During a charge cycle if the battery voltage is below the VPRECH threshold, the LP28009 applies a pre-charge mode to the battery. This feature revives deeply discharged cell sand protects battery life. The LP28009 internal determines the pre-charge rate as 10% of the fast-charge current. Battery Voltage Regulation. The LP28009 monitors the battery voltage through the BATT pin. Once the battery voltage level closes to the VREG threshold, the LP28009 voltage enters constant phase and the charging current begins to taper down. When battery voltage is over the VREG threshold, the LP28009 will stop charge and keep to monitor the battery voltage. However, when the battery voltage decreases 100mV below the VREG, it will be recharged to keep the battery voltage. Charge Status Outputs. The open-drain CHG_S and PGOOD outputs indicate various charger operations as shown in the following table. These status pins can be used to drive LEDs or communicate to the host processor. Note that ON indicates the open-drain transistor is turned on and LED is bright.

| Charge State | | $\overline{CHG_S}$ | $\overline{PGOOD}$ |
|---|---|---|---|
| ACIN | Charge | ON | ON |
| | Charge done | OFF | ON |

**Temperature Regulation and Thermal Protection**

In order to maximize the charge rate, the LP28009 features a junction temperature regulation loop. If the power dissipation of the IC results in a junction temperature greater than the thermal regulation threshold (125°C), theLP28009 throttles back on the charge current in order to maintain a junction temperature around the thermal regulation threshold (125°C). The LP28009 monitors the junction temperature, TJ, of the die and disconnects the battery from the input if TJ exceeds 125°C. This operation continues until junction temperature falls below thermal regulation threshold (125°C) by the hysteresis level. This feature prevents the chip from damage.

**Selecting the Input and Output Capacitors**

In most applications, the most important is the high-frequency decoupling capacitor on the input of the LP28009.A 1uF ceramic capacitor, placed in close proximity to input pin and GND pin is recommended. In some applications depending on

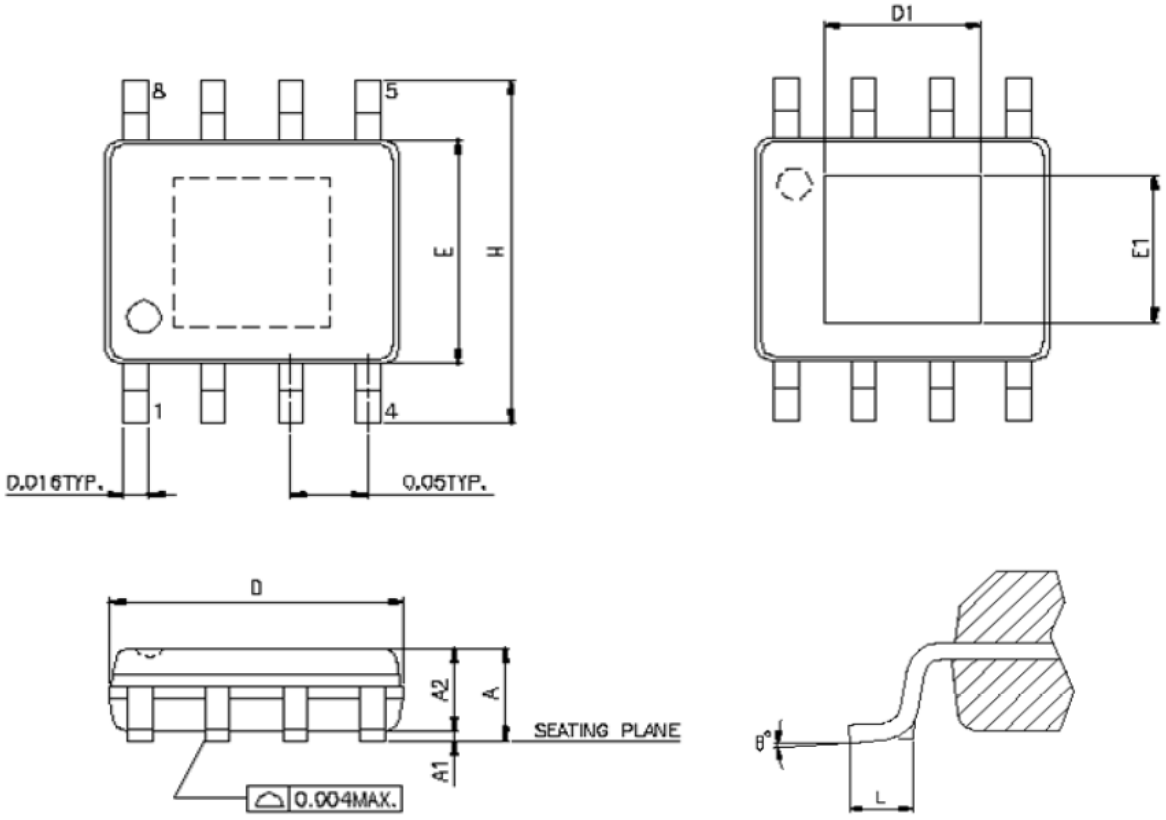
the power supply characteristics and cable length, it may be necessary to add an additional 10uFceramic capacitor to the input.
The LP28009 requires a small output capacitor for loop stability. A 1uF ceramic capacitor placed between the BATT pin and GND is typically sufficient.

**Layout Consideration**

The LP28009 is a fully integrated low cost single-cell Li-Ion battery charger ideal for portable applications. Careful PCB layout is necessary. For best performance, place all peripheral components as close to the IC as possible. A short connection is highly recommended. The following guide lines should be strictly followed when designing a PCB layout for the LP28009.Input capacitor should be placed close to IC and connected to ground plane.
The trace of input in the PCB should be placed far away the sensitive devices or shielded by the ground.
The GND should be connected to a strong ground plane for heat sinking and noise protection. The connection of RSETA should be isolated from other noisy traces.
The short wire is recommended to prevent EMI and noise coupling.
Output capacitor should be placed close to IC and connected to ground plane to reduce noise coupling.
The capacitance (0.1uF to10uF) base on PCB layout. When PCB has poor layout, the 10uF is recommended to prevent noise.

## Packaging Information

### E-SOP-8L




| SYMBOL | COMMON | | | | | |
|---|---|---|---|---|---|---|
| | DIMENSIONS MILLIMETER | | | DIMENSIONS INCH | | |
| | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |
| A | 1.35 | - | 1.75 | 0.053 | - | 0.069 |
| A1 | 0.05 | | 0.15 | 0.002 | - | 0.006 |
| A2 | - | - | 1.50 | - | - | 0.059 |
| b | 0.4 BSC | | | 0.016 BSC | | |
| D | 4.8 | - | 5.0 | 0.189 | - | 0.196 |
| D1 | 2.97 REF | | | 0.117 REF | | |
| E | 3.8 | - | 4.0 | 0.150 | - | 0.157 |
| E1 | 2.18 REF | | | 0.086 REF | | |
| e | 1.27 BSC | | | 0.05 BSC | | |
| H | 5.8 | - | 6.2 | 0.228 | - | 0.244 |
| L | 0.4 | - | 1.27 | 0.016 | - | 0.050 |
| θ | 0 | - | 8 | 0 | - | 8 |

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