



### Features

- Preset 8.4V Charge Voltage with 1% Accuracy
- Programmable Charge Current Up to 1A
- Input Voltage: 9.2V ~ 13V
- Pre-Charging, the Charge Current is adjustable
- Ideal for Dual-Cell (8.4V) Li-Ion Batteries
- Constant -Current Charging, the Charge Current is adjustable
- Constant-Voltage Charging
- Constant-Current/Constant-Voltage Charging with Temperature Monitoring
- Automatic Recharge
- Double LEDs Charge Status Indication
- Available in SOP-8L Package

### Applications

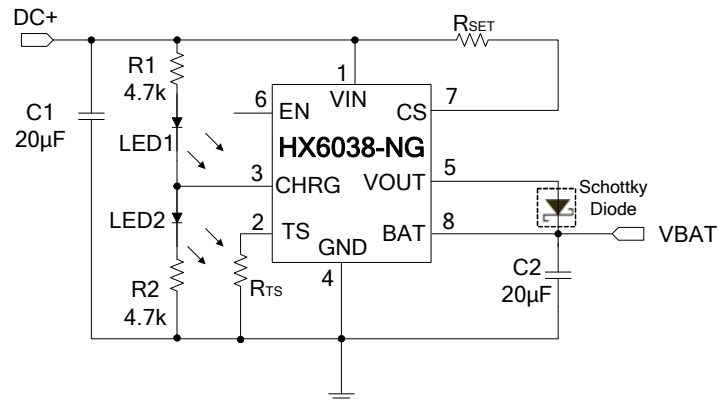
- Charger for Li-Ion Coin Cell Batteries
- Bluetooth Applications
- Portable MP3 Players, Wireless Headsets

### Description

The HX6038-NG is a highly advanced complete constant-current/ constant voltage linear charger for cell lithium-ion batteries. Its package and low external component count make the HX6038-NG ideally suited for portable applications. The charge current can be programmed externally with a single resistor, which may be programmed up to 1A. HX6038-NG determines the charge mode by detecting the battery voltage: Pre-charge, constant current charging, constant voltage charging. The charge current of Opre-charging and constant –current charging is adjustable. The HX6038-NG is monitored by temperature monitor during the constant-current and constant-voltage charging. There are two LEDs indicate the charge mode.

The HX6038-NG is available in the SOP-8L package.

## Typical Application Circuit



- \* The charge current  $I_{O(REG)} = V_{CS} / R_{SET}$  ( $V_{CS}$  is usually 200mV). Note that OFF indicates the LED is turned off.
- \* The reverse-blocking protection diode is optional. In addition, the reverse-leakage current of the diode should be kept as small as possible.

## Pin Assignment and Description

| TOP VIEW |  | PIN | NAME | DESCRIPTION                     |
|----------|--|-----|------|---------------------------------|
|          |  | 1   | VIN  | Positive Input Supply Voltage.  |
|          |  | 2   | TS   | Temperature Sense               |
|          |  | 3   | CHRG | Open-Drain Charge Status Output |
|          |  | 4   | GND  | Ground                          |
|          |  | 5   | VOUT | Charge Current Output           |
|          |  | 6   | EN   | ON/OFF Control (High Enable)    |
|          |  | 7   | CS   | Charge Current Program          |
|          |  | 8   | BAT  | Battery Connection              |

## Absolute Maximum Ratings (Note 1)

- Input Supply Voltage (VIN) ..... -0.3V to 18V
- TS、CHRG、CS ..... - 0.3V to VIN + 0.3V
- VOUT Pin Current ..... 1A
- Maximum Junction Temperature ..... 150°C
- Operating Ambient Temperature Range (Note 2)..... -40°C to 85°C
- Storage Temperature Range ..... -65°C to 125°C
- Lead Temperature (Soldering, 10 sec).....265°C

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

**Note 2:** The HX6038-NG is guaranteed to meet performance specifications from 0°C to 70°C. Specifications over the -40°C to 85°C operating temperature range are assured by design, characterization and correlation with statistical process controls.

## Electrical Characteristics

Operating Conditions:  $T_A=25^{\circ}\text{C}$ .

| SYMBOL  | PARAMETER                          | CONDITIONS                                     | MIN   | TYP   | MAX   | UNITS         |
|---|------------------------------------|--|-------|-------|-------|---------------|
| $V_{IN}$  | Input Supply Voltage               |  | 9.2   |       | 13    | V             |
| $V_{IN(OVLO)}$  | OVLO Threshold                     | $V_{IN}$ Rising                                |       | 14    |       | V             |
| $I_{IN}$  | Input Supply Current               | Standby Mode (Charge Terminated) I             |       | 0.25  |       | mA            |
| $I_{SLEEP}$   | Sleep Current                      | Sum of currents into VOUT pin, $V_{IN}=0$      |       | 25    |       | $\mu\text{A}$ |
| <b>Battery Voltage Regulation Constant-current Charge</b>           |                                    |  |       |       |       |               |
| $V_{O(REG)}$  | Output voltage                     |  | 8.317 | 8.4   | 8.484 | V             |
| $V_{(CS)}$  | Current regulation threshold       | Voltage at pin CS , relative to $V_{IN}$       | 180   | 200   | 220   | mV            |
| <b>Trickle Charge</b>   |                                    |  |       |       |       |               |
| $V_{TRIKL}$   | Trickle Charge Threshold Voltage   | $V_{BAT} < V_{TRIKL}$ , $R_{SET}=0.33\Omega$ . | 5.6   | 6     | 6.2   | V             |
| $I_{TRIKL}$   | Trickle Charge Current             | $V_{BAT}$ Rising, $R_{SET}=0.33\Omega$ .       |       | 60    |       | mA            |
| <b><math>V_{RCH}</math> comparator (Battery Recharge Threshold)</b> |                                    |  |       |       |       |               |
| $\Delta V_{(RCH)}$  | Recharge Battery Threshold Voltage | $V_{FLOAT} - V_{RECHRG}$                       |       | 500   |       | mV            |
| <b>Temperature Sense Comparator</b>                                 |                                    |  |       |       |       |               |
| $V_{TS-COLD}$   | TS Pin Threshold Voltage (Cold)    | $V_{TS}$ from Low to High                      |       | 2.486 |       | V             |
| $V_{TS-HOT}$  | TS Pin Threshold Voltage (Hot)     | $V_{TS}$ from High to Low                      |       | 0.485 |       | V             |
| $I_{TS}$  | TS Pin Output Current              |  |       | 85    |       | $\mu\text{A}$ |

## Pin Functions

**VIN (Pin 1):** Positive Input Supply Voltage. It Provides power to the charger VIN and should be bypassed with a 10uF capacitor.

**TS (Pin 2):** Temperature Sense.

**CHRG (Pin 3):** Charge Status Indication. When the battery is charging, the CHRG pin is pulled low. When the charge cycle is completed, the CHRG pin is pulled high. When no AC is detected, CHRG is forced high impedance.

**GND (Pin 4):** Ground.

**VOUT (Pin 5):** Charge Current Output. It provides charge current to the battery and regulates the final float voltage to 8.4V.

**EN (Pin 6):** En Control Input. Forcing this pin above 1V enables the part. Forcing this pin below 0.8V shuts down the device. In shutdown, all functions are disabled drawing <1uA supply current. Do not leave EN floating.

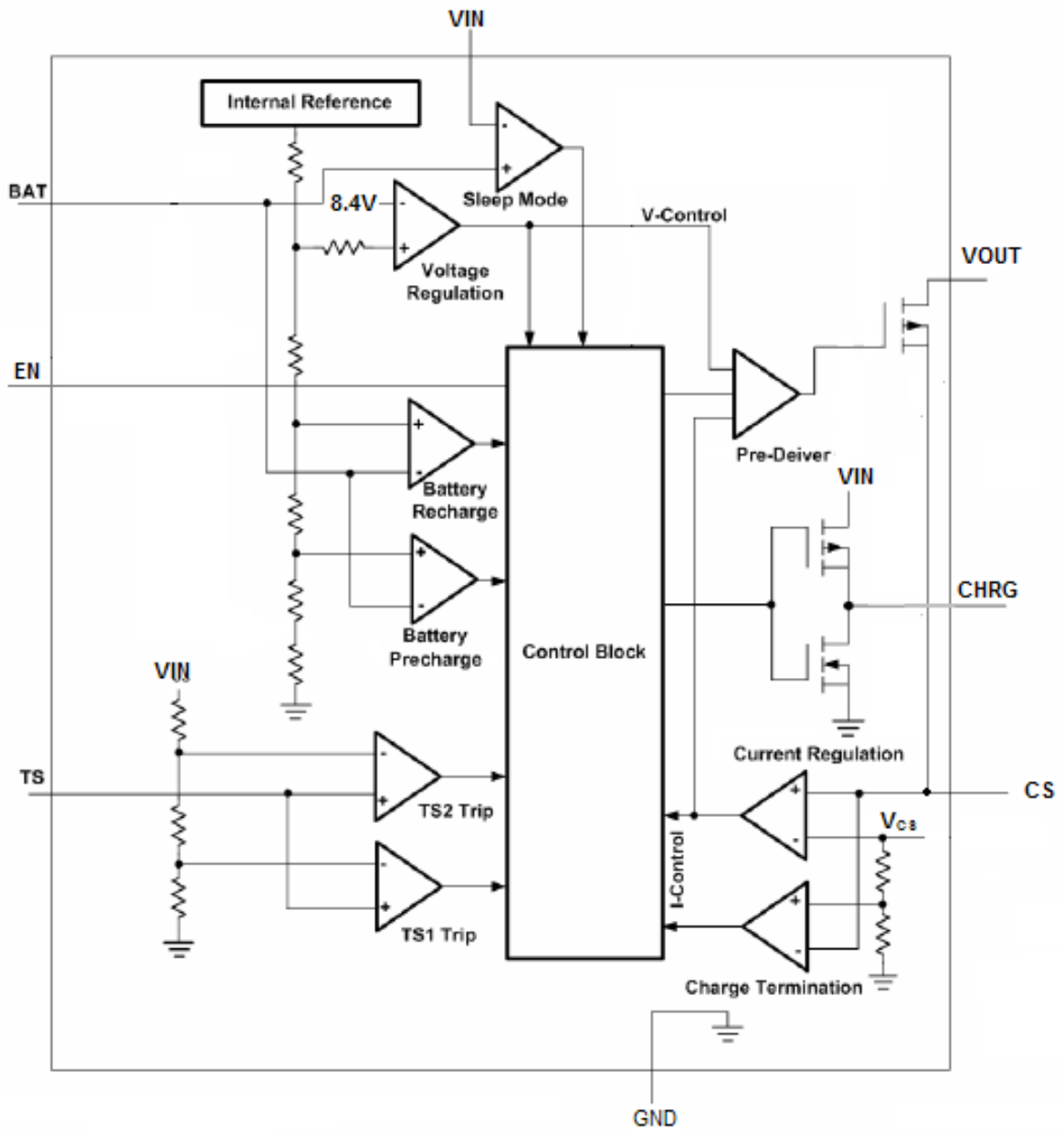
**CS (Pin 7):** Charge Current Program, Charge Current Monitor and Shutdown Pin. The charge current is programmed by connecting a resistor,  $R_{SET}$ .

**BAT (Pin 8):** Battery Connection.

**Table1. Charge Status Summary**

| Condition             | LED1 | LED2 |
|-----------------------|------|------|
| Battery charging      | ON   | OFF  |
| Charge complete(done) | OFF  | ON   |

Block Diagram



## Application Information

### Functional Description

The HX6038-NG is an advanced 1A linear charge controller for dual-cell Li-Ion or Li-Ion applications. Refer to Block Diagram and Operation Flow Chart (Figure 1) in this section.

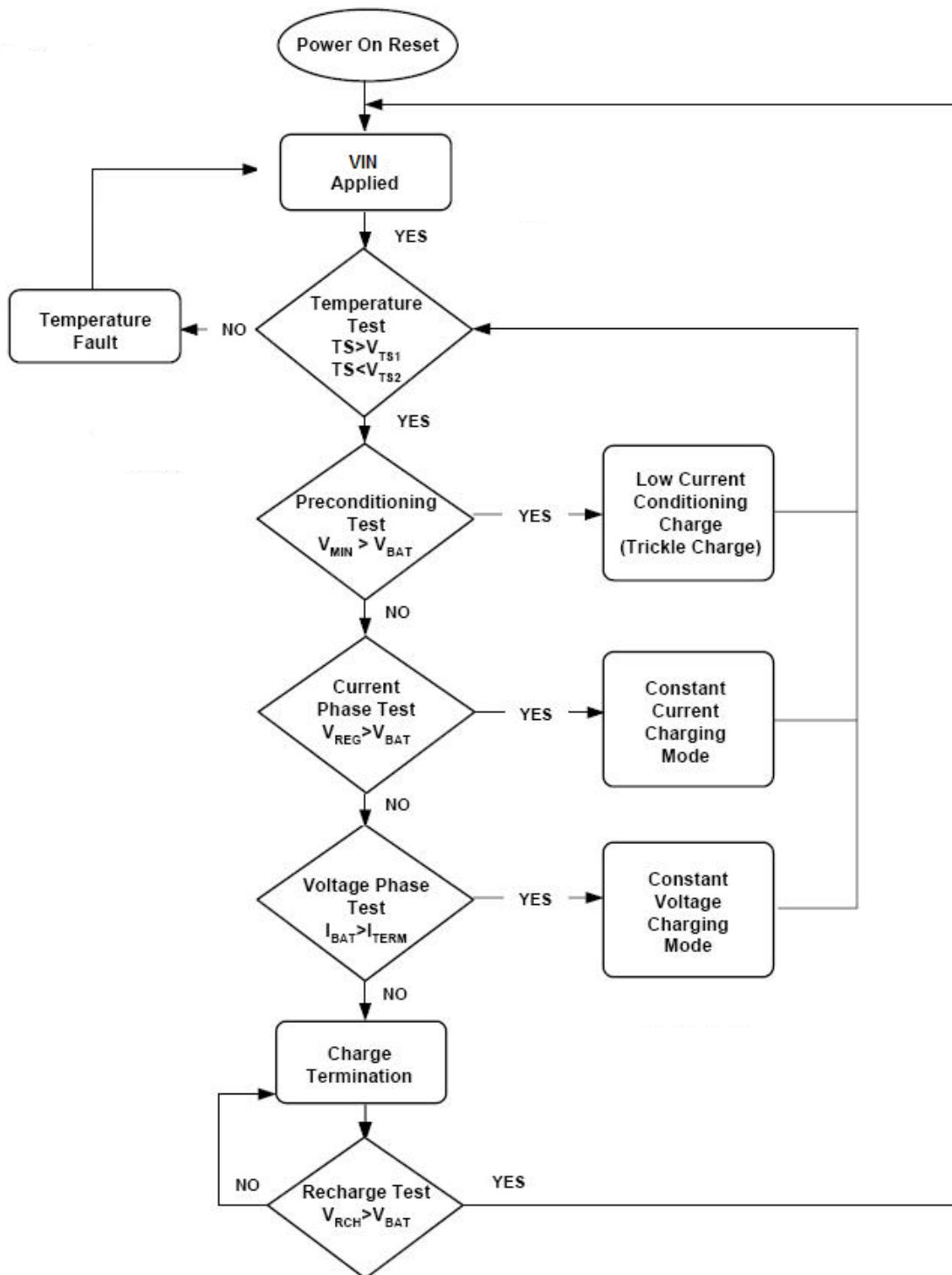


Figure 1: Operation Flow Chart

## Qualification and Precharge

When power is applied, the HX6038-NG starts a charge-cycle if a battery is already present or when a battery is inserted. Charge qualification is based on battery temperature and voltage.

The HX6038-NG suspends charge if the battery temperature is outside the  $V_{TS1}$  to  $V_{TS2}$  range and suspends charge until the battery temperature is within the allowed range. The HX6038-NG also checks the battery voltage. If the battery voltage is below the precharge threshold  $V_{(min)}$ , the HX6038-NG uses precharge to condition the battery. The conditioning charge rate  $I_{(PRECHG)}$  is set at approximately 10% of the regulation current. The conditioning current also minimizes heat dissipation in the external pass-element during the initial stage of charge. See Figure 2 for a typical charge-profile.

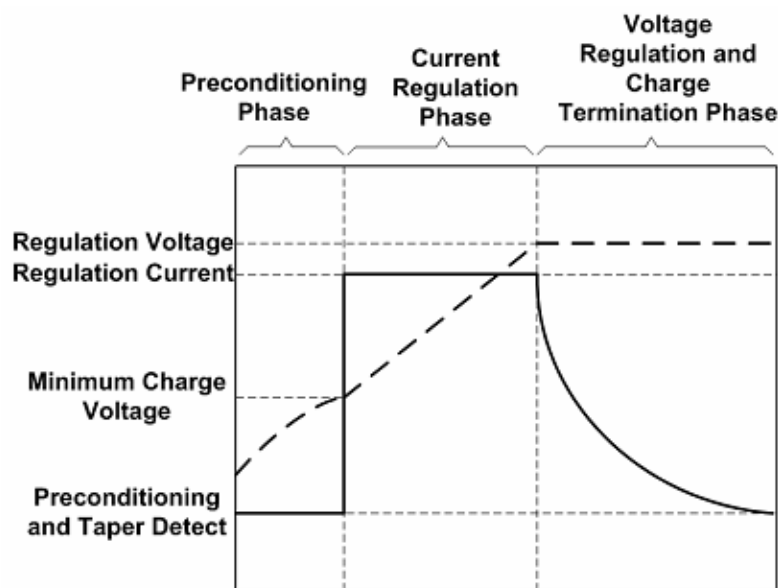


Figure 2: Typical Charge Profile

## Current Regulation Phase

The HX6038-NG regulates current while the battery-pack voltage is less than the regulation voltage,  $V_{O(REG)}$ . The HX6038-NG monitors charge current at the CS input by the voltage drop across a sense-resistor,  $R_{SET}$ , in series with the battery pack. In current sensing configuration,  $R_{SET}$  is between the VIN and CS pins, charge-current feedback, applied through pin CS, maintains a voltage of  $V_{CS}$  across the current sense resistor. The following formula calculates the value of the Sense resistor:

$$R_{SET} = \frac{V_{CS}}{I_{O(REG)}}$$

Where,  $I_{O(REG)}$  is the desired charging current.

## Voltage Phase

The voltage regulation feedback is through the BAT pin. This input is tied directly to the positive side of the battery pack. The HX6038-NG monitors the battery-pack voltage between the BAT and GND pins. The HX6038-NG is offered 8.4V output voltage.

### **Charge Termination Recharge**

The HX6038-NG monitors the charging current during the voltage-regulation phase. The HX6038-NG declares a done condition and terminates charge when the current drops to the charge termination threshold,  $I_{TERM}$ . A new charge cycle begins when the battery voltage falls below the  $V_{RCH}$  threshold.

### **Battery Temperature Monitoring**

A negative temperature coefficient (NTC) thermistor located close to the battery pack can be used to monitor battery temperature and will not allow charging unless the battery temperature is within an acceptable range.

Connect a 10k thermistor from the TS pin to ground. With the 85 $\mu$ A pull-up current source, the hot temperature voltage threshold is 485mV. For cold temperature, the voltage threshold is set at 2.486V with 85 $\mu$ A of pull-up current. The charge cycle begins or resumes once the temperature is within the acceptable range.

### **Reverse Blocking Protection**

The optional reverse-blocking protection diode, depicted in Figure1 provides protection from a faulted or shorted input, or from a reversed-polarity input source. Without the protection diode, a faulted or shorted input would discharge the battery pack through the body diode of the external pass transistor.

If a reverse-protection diode is incorporated in the design, it should be chosen to handle the fast charge current continuously at the maximum ambient temperature. In addition, the reverse-leakage current of the diode should be kept as small as possible.

### **Selecting Input Capacitor**

In most applications, all that is high-frequency decoupling capacitor. The HX6038-NG works with both regulated and unregulated external dc supplies. If a non-regulated supply is chosen, the supply voltage to the minimum required input voltage at maximum load. If not, more capacitance must be added to the input of the charger.

### **Selecting Output Capacitor**

The HX6038-NG does not require any output capacitor for loop stability.

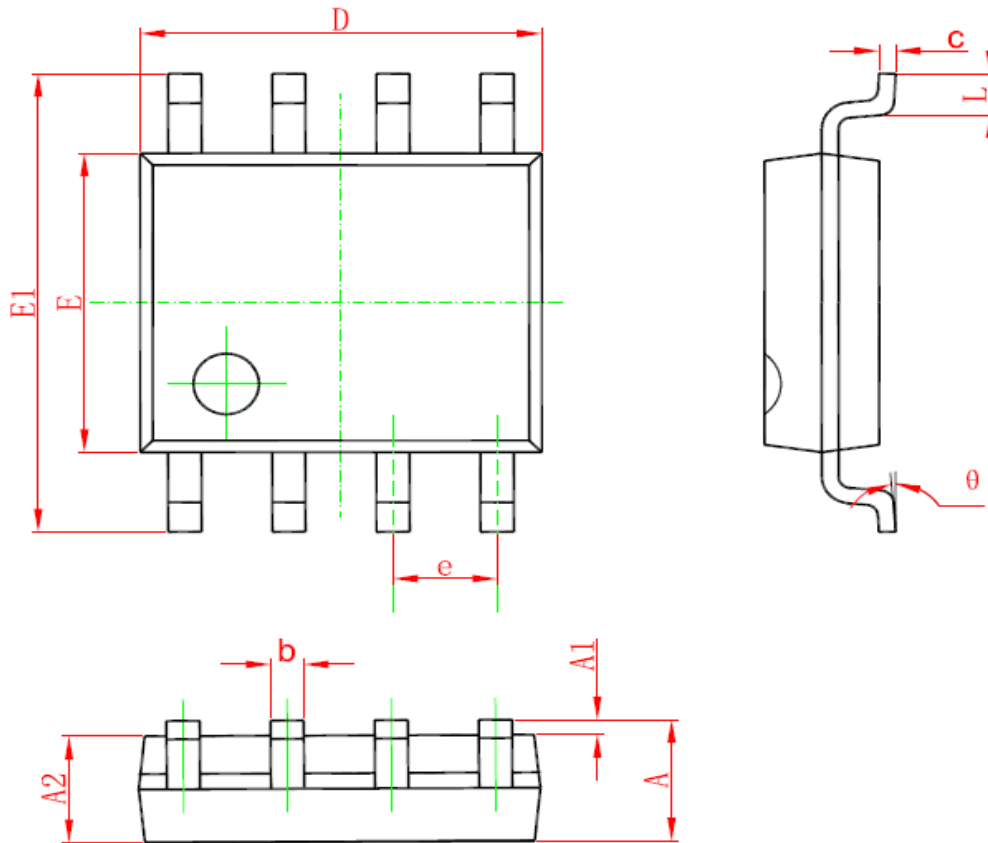
In order to maintain good AC stability in constant Voltage mode, a minimum capacitance of 10 $\mu$ F is recommended to bypass the BAT pin to GND. This capacitance provides compensation when there is no battery load. In addition, the battery and interconnections appear inductive at high frequencies. These elements are in the control feedback loop during Constant Voltage mode. Therefore, the bypass capacitance may be necessary to compensate for the inductive nature of the battery pack.

Virtually any good quality output filter capacitor can be used, independent of the capacitor's minimum ESR (Effective Series Resistance) value. The actual value of the capacitor and its associated ESR depends on the forward transconductance (gm) and capacitance of the external pass transistor. A 10 $\mu$ F tantalum or aluminum electrolytic capacitor at the output is usually sufficient to ensure stability for up to a 1A output current.



## Packaging Information

### SOP-8L Package Outline Dimension



| Symbol | Dimensions In Millimeters |       | Dimensions In Inches |       |
|--------|---------------------------|-------|----------------------|-------|
|        | Min                       | Max   | Min                  | Max   |
| A      | 1.350                     | 1.750 | 0.053                | 0.069 |
| A1     | 0.100                     | 0.250 | 0.004                | 0.010 |
| A2     | 1.350                     | 1.550 | 0.053                | 0.061 |
| b      | 0.330                     | 0.510 | 0.013                | 0.020 |
| c      | 0.170                     | 0.250 | 0.006                | 0.010 |
| D      | 4.700                     | 5.100 | 0.185                | 0.200 |
| E      | 3.800                     | 4.000 | 0.150                | 0.157 |
| E1     | 5.800                     | 6.200 | 0.228                | 0.244 |
| e      | 1.270(BSC)                |       | 0.050(BSC)           |       |
| L      | 0.400                     | 1.270 | 0.016                | 0.050 |
| θ      | 0°                        | 8°    | 0°                   | 8°    |

Subject changes without notice.