# 1A Standalone Linear Li-Ion Battery Charger

## General Description

The LP4053 is a complete constant-current/constant- voltage linear charger for single cell lithium-ion batteries. Its SOT23-6/ESOP-8 package and low external component count make the LP4053 ideally suited for portable applications. Furthermore, the LP4053 is specifically designed to work within USB power specifications. No external sense resistor is needed, and no blocking diode is required due to the internal MOSFET architecture. Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature. The charge voltage is fixed at 4.2V, and the charge current can be programmed externally with a single resistor. When the input supply (wall adapter or USB supply) is removed, the LP4053 automatically enters a low current state, dropping the battery drain current to less than 1μA. Other features include charge current monitor, automatic recharge and a status pin to indicate charge termination and the presence of an input voltage.

## Order Information

LP4053 □□ □

- F: Pb-Free
- Package Type
  - B6: SOT23-6
  - SP: ESOP-8

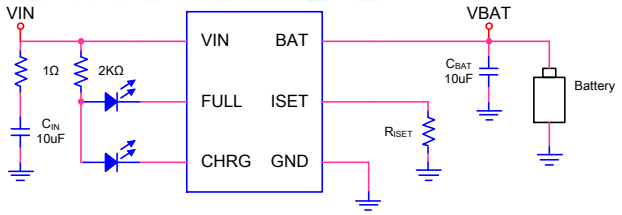
## Applications

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

## Features

- ◆ Programmable Charge Current Up to 1A
- ◆ No MOSFET, Sense Resistor or Blocking Diode Required
- ◆ Constant-Current/Constant-Voltage Operation with Thermal Regulation to Maximize
- ◆ Protection of Reverse Connection of Battery
- ◆ Charge Rate Without Risk of Overheating
- ◆ 4.2V Charge Voltage with ± 1% Accuracy
- ◆ Charge Current Monitor Output for Gas Gauging
- ◆ Automatic Recharge
- ◆ 2.9V Trickle Charge Threshold
- ◆ Charging OTP
- ◆ Package in SOT23-6/ESOP-8

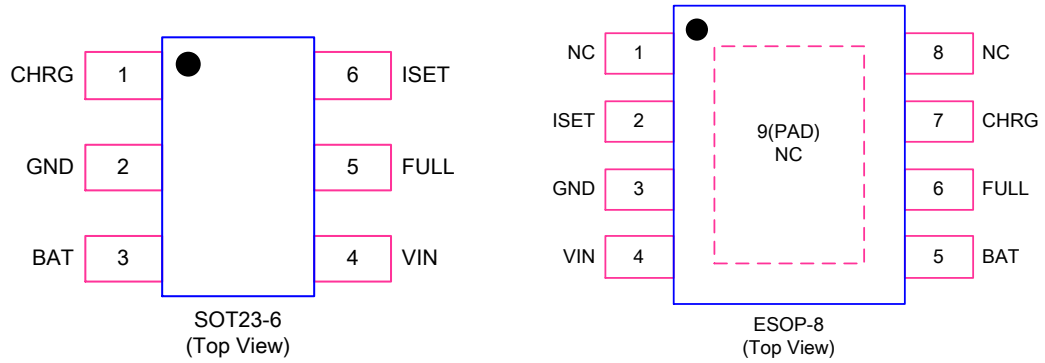
## Typical Application Circuit




## Marking Information

| Device | Marking | Package | Shipping |
|---|---|---|---|
| LP4053B6F | LP4053<br>YWXXX | SOT23-6 | 3K/REEL |
| LP4053SPF | LPS<br>LP4053<br>YWXXX | ESOP8 | 4K/REEL |
| Marking indication:<br>Y:Production year W:Production week X: Series Number | | | |

## Functional Pin Description

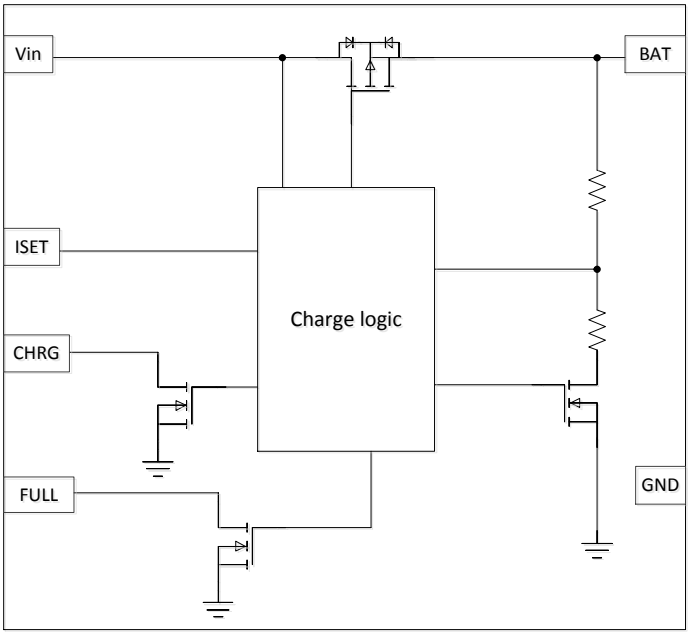
| Package Type | Pin Configurations |
|---|---|
| SOT23-6 / ESOP-8 |  |



## Pin Description

| Pin No. | | Name | Description |
|---|---|---|---|
| SOT23-6 | ESOP-8 | | |
| 1 | 7 | CHRG | Open-Drain Charge Status Output. When the battery is charging, the CHRG pin is pulled low by an internal N-channel MOSFET. |
| 2 | 3 | GND | Ground. |
| 3 | 5 | BAT | Charge Current Output. Provides charge current to the battery and regulates the final float voltage to 4.2V. |
| 4 | 4 | VIN | Positive Input Supply Voltage. |
| 5 | 6 | FULL | Open-Drain Charge Status Output. When the battery is fully charge, the FULL pin is pulled low by an internal N-channel MOSFET. |
| 6 | 2 | ISET | Charge Current Program and Charge Current Monitor Pin. The charge current is programmed by connecting a 1% resistor, $R_{ISET}$, to ground. When charging in constant-current mode, this pin servos to 1V. In all modes, the voltage on this pin can be used to measure the charge current using the following formula: $$I_{BAT} = 1000 \times \frac{V_{ISET}}{R_{ISET}}$$ |
| | 1/8/ 9(PAD) | NC | No Connector. |

## Function Block Diagram




## Absolute Maximum Ratings Note 1

- ✧ VIN to GND ---------- -0.3V to 10V
- ✧ BAT to GND(VIN) ---------- -5V to 10V
- ✧ Other Pin to GND ---------- -0.3V to 8V
- ✧ BAT Short-circuit Duration ---------- Continuous
- ✧ Maximum Junction Temperature ---------- 125℃
- ✧ Operating Junction Temperature Range ($T_J$) ---------- -20℃ 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 (SOT23-6, $P_D$, $T_A$=25℃) ---------- 0.45W
- ✧ Thermal Resistance (SOT23-6, $\theta_{JA}$) ---------- 250℃/W
- ✧ Maximum Power Dissipation (ESOP-8, $P_D$, $T_A$=25℃) ---------- 2W
- ✧ Thermal Resistance (ESOP-8,$\theta J_A$) ---------- 50℃/W

## ESD Susceptibility

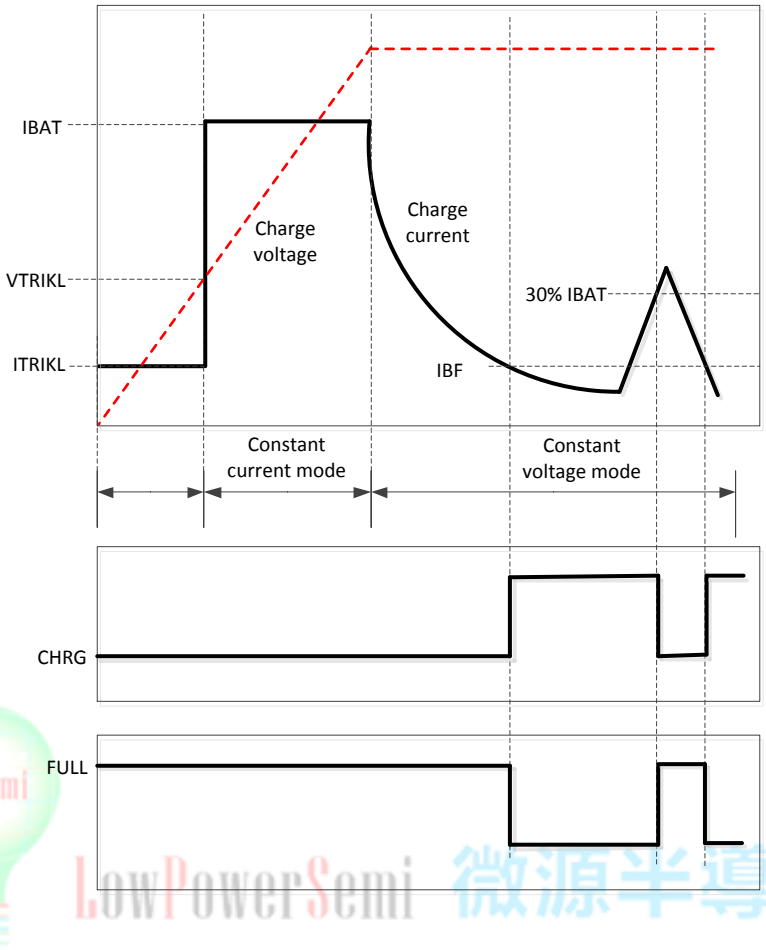
- ✧ HBM(Human Body Mode) ---------- 2KV
- ✧ MM(Machine Mode) ---------- 200V

## Electrical Characteristics

($T_A$=25℃, $V_{IN}$ = 5V, unless otherwise noted.)

| SYMBOL | PARAMETER | CONDITIONS | MIN | TYP. | MAX | UNITS |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Adapter/USB Voltage Range | | | 5 | | V |
| $I_{IN}$ | Input Supply Current | Standby Mode (Charge Terminated) | | 50 | | uA |
| $V_{FLOAT}$ | Regulated Output (Float) Voltage | $I_{BAT}$ = 40mA | 4.158 | 4.2 | 4.242 | V |
| $I_{BAT}$ | BAT Pin Current | $R_{ISET}$ = 10K, Current Mode | | 100 | | mA |
| | | $R_{ISET}$ = 2K, Current Mode | | 500 | | |
| | | Standby Mode, $V_{BAT}$ = 4.2V<br>Sleep Mode, $V_{IN}$ = 0V | | ±0.1 | ±1 | uA |
| $V_{TRIKL}$ | Trickle Charge Threshold Voltage | $R_{ISET}$ = 10k, $V_{BAT}$ Rising | | 2.9 | | V |
| $V_{TRHYS}$ | Trickle Charge Hysteresis Voltage | $R_{ISET}$ = 10K | | 150 | | mV |
| $I_{TRIKL}$ | Trickle Charge Current | $V_{BAT}$ < $V_{TRIKL}$, $R_{ISET}$ = 10K | | 10 | | mA |
| | | $V_{BAT}$ < $V_{TRIKL}$, $R_{ISET}$ = 2K | | 50 | | |
| $V_{UV}$ | $V_{IN}$ Undervoltage Lockout Threshold | From $V_{IN}$ Low to High | | 3.8 | | V |
| $V_{UVHYS}$ | $V_{IN}$ Undervoltage Lockout Hysteresis | | | 200 | | mV |
| $V_{ASD}$ | $V_{IN}$–$V_{BAT}$ Lockout Threshold Voltage | | | 150 | | mV |
| $I_{BF}$ | Battery Full Programming Range | | | 10 | | % $I_{BAT}$ |
| $V_{ISET}$ | ISET Pin Voltage | $R_{ISET}$ = 10K, Charge Mode | | 1 | | V |
| $V_{STAT}$ | CHRG/FULL Pin Output Low Voltage | $I_{STAT}$ = 5mA | | | 0.5 | V |
| $I_{STAT}$ | CHRG/FULL Pin Weak Pull-Down Current | $I_{STAT}$ = 5V | | | 5 | uA |
| $T_{LIMIT}$ | Unction Temperature In Constant Temperature Mode | | | 125 | | ℃ |

## Charge Current Characteristics



# Application Information

The LP4053 is a single cell lithium-ion battery charger using a constant-current/constant-voltage algorithm. It can deliver up to 1A of charge current (using a good thermal PCB layout) with a final float voltage accuracy of ±1%. The LP4053 includes an internal P-channel power MOSFET and thermal regulation circuitry. No blocking diode or external current sense resistor is required; thus, the basic charger circuit requires only three external components. Furthermore, the LP4053 is capable of operating from a USB power source.

### Normal Charge Cycle

A charge cycle begins when the voltage at the VIN pin rises above the UVLO threshold level and a 1% program resistor is connected from the ISET pin to ground or when a battery is connected to the charger output. If the BAT pin is less than 2.9V, the charger enters trickle charge mode.

When the BAT pin voltage rises above 2.9V, the charger enters constant-current mode, where the programmed charge current is supplied to the battery. When the BAT pin approaches the final float voltage (4.2V), the LP4053 enters constant-voltage mode and the charge current begins to decrease and the battery full indication is set when the charge current in the CV mode is reduced to the programmed full battery current ($I_{BF}$).

### Charge Status Indicator (CHRG, FULL)

The LP4053 has two status pin, CHRG and FULL. Once the charge current drops to the battery full charge current threshold ($I_{BF}$), the CHRG pin will become high impedance. After that, when the charging current increases to 30% of $I_{BAT}$, CHRG pin returns to be pulled low by an internal N-channel MOSFET until the charging current decreases to 10% of $I_{BAT}$ again.

The state of the FULL pin is always opposite to the CHRG pin

### Programming Charge Current

The charge current is programmed 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 program resistor and the charge current are calculated using the following equations:

$$R_{ISET} = \frac{1000}{I_{BAT}}$$

$$I_{BAT} = \frac{1000}{R_{ISET}}$$

The charge current out of the BAT pin can be determined at any time by monitoring the ISET pin voltage using the following equation:

$$I_{BAT} = 1000 \times \frac{V_{ISET}}{R_{ISET}}$$

### Thermal Limit

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 125℃. This feature protects the LP4053 from excessive temperature and allows the user to push the limits of the power handling capability of a given circuit board without risk of damaging the LP4053. The charge current can be set according to typical (not worst-case) ambient temperature with the assurance that the charger will automatically reduce the current in worst-case conditions.

### Power Dissipation

The conditions that cause the LP4053 to reduce charge current through thermal feedback can be approximated by considering the power dissipated in the IC. Nearly all of this power dissipation is generated by the internal MOSFET this is calculated to be approximately:

$$P_D = (V_{IV} - V_{BAT}) \times I_{BAT}$$

### VIN Bypass Capacitor

Many types of capacitors can be used for input bypassing; however, caution must be exercised when using multilayer ceramic capacitors. Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, high voltage transients can be generated under some start-up conditions, such as connecting the charger input to a live power source. Adding a 1Ω resistor in series with an X5R ceramic capacitor will minimize start-up voltage transients.

### Layout Considerations

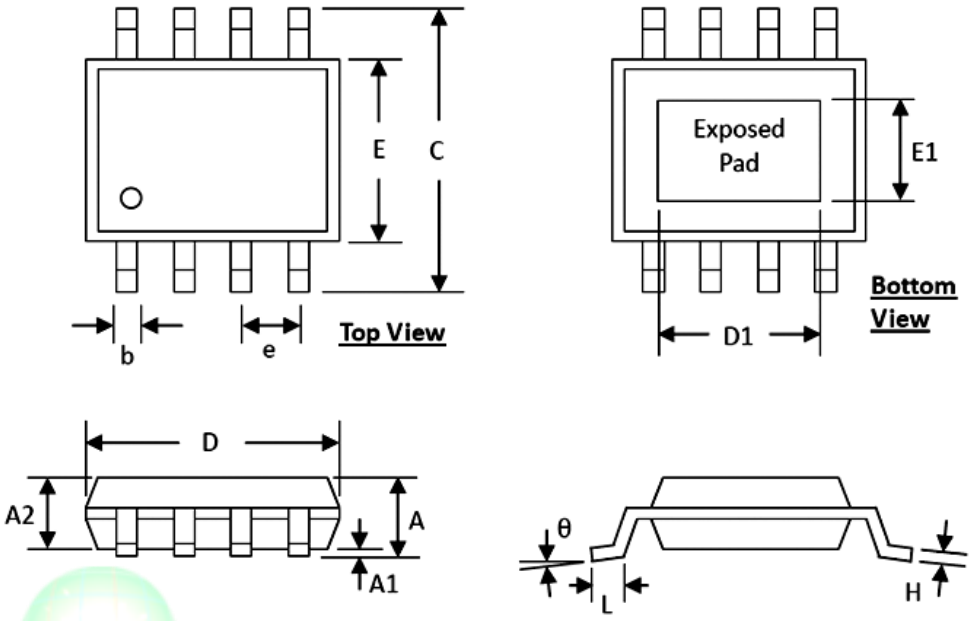
✧ For the main current paths as indicated in bold lines, keep their traces short and wide.

✧ Put the input capacitor as close as possible to the device pins (VIN and GND).

✧ Connect all analog grounds to a command node and then connect the command node to the power ground behind the output capacitors.

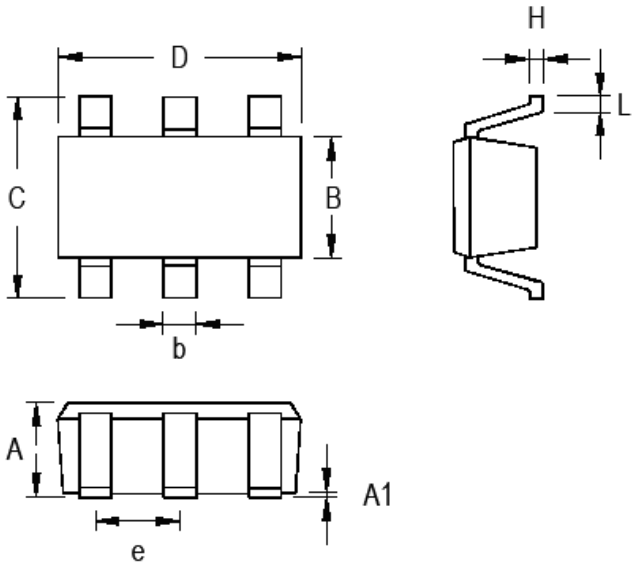
## Packaging Information

**ESOP-8**




| SYMBOLS | DIMENSION (MM) | | DIMENSION (INCH) | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.30 | 1.70 | 0.051 | 0.067 |
| A1 | 0.00 | 0.15 | 0.000 | 0.006 |
| A2 | 1.25 | 1.52 | 0.049 | 0.060 |
| b | 0.33 | 0.51 | 0.013 | 0.020 |
| C | 5.80 | 6.20 | 0.228 | 0.244 |
| D | 4.80 | 5.00 | 0.189 | 0.197 |
| D1 | 3.15 | 3.45 | 0.124 | 0.136 |
| E | 3.80 | 4.00 | 0.150 | 0.157 |
| E1 | 2.26 | 2.56 | 0.089 | 0.101 |
| e | 1.27 BSC | | 0.050 BSC | |
| H | 0.19 | 0.25 | 0.0075 | 0.0098 |
| L | 0.41 | 1.27 | 0.016 | 0.050 |
| θ | 0° | 8° | 0° | 8° |

## SOT23-6




| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 0.889 | 1.295 | 0.031 | 0.051 |
| A1 | 0.000 | 0.152 | 0.000 | 0.006 |
| B | 1.397 | 1.803 | 0.055 | 0.071 |
| b | 0.250 | 0.560 | 0.010 | 0.022 |
| C | 2.591 | 2.997 | 0.102 | 0.118 |
| D | 2.692 | 3.099 | 0.106 | 0.122 |
| e | 0.838 | 1.041 | 0.033 | 0.041 |
| H | 0.080 | 0.254 | 0.003 | 0.010 |
| L | 0.300 | 0.610 | 0.012 | 0.024 |