Features

- Programmable Charge Current up to 900mA
- No MOSFET, Sense Resistor or Blocking Diode Required
- Constant-Current/Constant-Voltage Operation with Thermal Regulation to Maximize Charge Rate
- Charges Single Cell Li-Ion Batteries Directly from USB Port
- Preset 4.22V Charge Voltage with 1% Accuracy
- Automatic Recharge
- 2.8V Trickle Charge Threshold
- Available in SOP8-PP Package

Applications

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

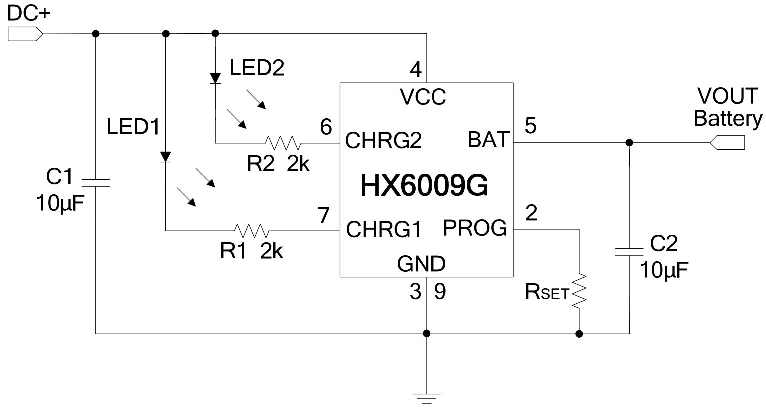
Description

The HX6009G is a complete constant current /constant voltage linear charger for single cell lithium-ion batteries. Its package and low external component count make the HX6009G ideally suited for portable applications. Furthermore, the HX6009G is specifically designed to work within USB power specifications.

The charge voltage is fixed at 4.22V, and the charge current can be programmed externally with a single resistor. The HX6009G automatically terminates the charge cycle when the charge current drops to 1/10th the programmed value after the final float voltage is reached.

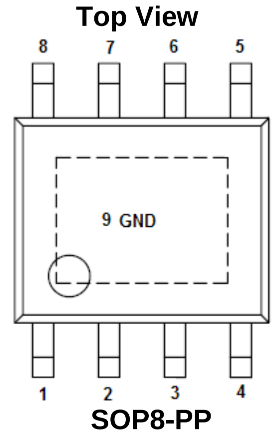
The HX6009G converters are available in the industry standard SOP8-PP power packages (or upon request).

Typical Application Circuit



* $I_{BAT} = (V_{PROG}/R_{SET}) \cdot 900$.
*When charging in constant-current mode, the V_{PROG} is usually 1V.

Pin Assignment



PIN	NAME	DESCRIPTION
1,8	NC	No Connect
2	PROG	Charge Current Program
3, 9	GND	Ground
4	VCC	Positive Input Supply Voltage
5	BAT	Charge Current Output
6	CHRG2	Charge Complete Status Output
7	CHRG1	Open-Drain Charge Status Output

Absolute Maximum Ratings (Note 1)

- Input Supply Voltage (V_{CC}) .... –0.3V ～ 7V
- PROG.. –0.3V ～ V_{CC} + 0.3V
- BAT ....–0.3V ～ 7V
- CHRG1, CHRG2..–0.3V ～ 7V
- BAT Pin Current 1A
- Maximum Junction Temperature .... +150℃
- Operating Ambient Temperature Range (Note 2)..–40℃ ～ +85℃
- Storage Temperature Range ....–65℃ ～ +125℃
- Lead Temperature (Soldering, 10 sec).. +265℃

Note 1: Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note 2: The HX6009G is guaranteed to meet performance specifications from 0℃ to 70℃. Specifications over the –40℃ to 85℃ operating temperature range are assured by design, characterization and correlation with statistical process controls.

Electrical Characteristics

Operating Conditions: T_A=25℃, V_{CC}=5V, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{CC}	Input Supply Voltage		4.5	5.0	6.5	V
I_Q	Input Supply Current	Standby Mode (Charge Terminated)		43		μA
		Shutdown Mode (R_{PROG} Not Connected, V_{CC} < V_{BAT})		80		μA
Battery Voltage Regulation Constant-Current Charge						
V_{FLOAT}	Regulated Output (Float) Voltage	0℃≤T_A≤85℃	4.18	4.22	4.27	V
I_{BAT}	BAT Pin Current	R_{PROG} = 10k, Current Mode		90		mA
		R_{PROG} = 1.5k, Current Mode		600		mA
		Standby Mode, V_{BAT} = 4.22V		-7		μA
		Shutdown Mode (R_{PROG} Not Connected)		±13		μA
		Sleep Mode, V_{CC} = 0V		±0.2	±2	μA
I_{MBAT}	Maximum Charge Current	R_{PROG} = 0.9k		900		mA
V_{PROG}	PROG Pin Voltage	R_{PROG} = 1.5k, Current Mode	0.95	1	1.05	V
Trickle Charge						
V_{TRIKL}	Trickle Charge Threshold Voltage	R_{PROG} = 10k, V_{BAT} Rising		2.8		V
I_{TERM}	C/10 Termination Current Threshold	R_{PROG} = 1.5k		58		mA
V_{RECHRG} Comparator (Battery Recharge Threshold)						
ΔV_{RECHRG}	Recharge Battery Threshold Voltage	V_{FLOAT} - V_{RECHRG}		220		mV

Pin Description

NC (Pin 1, 8): No Connect.

PROG (Pin 2): Charge Current Program, Charge Current Monitor and Shutdown Pin. The charge current is programmed by connecting a 1% resistor, R_{PROG}, 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: $I_{BAT} = (V_{PROG}/R_{SET}) \bullet 900$.

GND (Pin 3, 9): Ground.

VCC (Pin 4): Positive Input Supply Voltage. It Provides power to the charger VCC can range from 4.5V to 6.5V and should be bypassed with at least a 10μF capacitor.

BAT (Pin 5): Charge Current Output. It should be bypassed with at least a 10μF capacitor. It Provides charge current to the battery and regulates the final float voltage to 4.22V. An internal precision resistor divider from this pin sets the float voltage which is disconnected in shutdown mode.

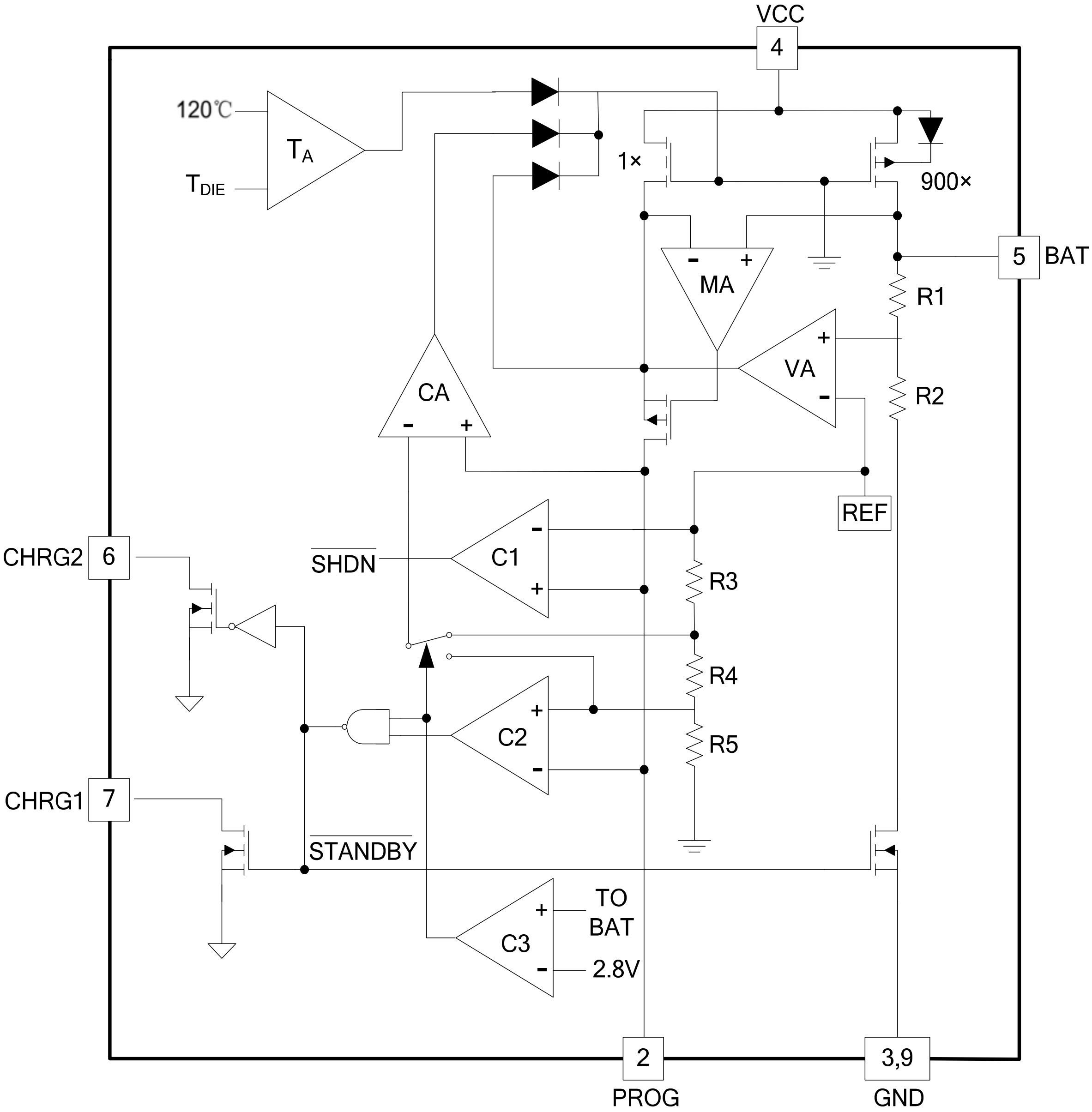
CHRG2 (Pin 6): Charge Complete Status Output. See CHRG1 pin (Pin 7).

CHRG1 (Pin 7): Open-Drain Charge Status Output. When the battery is charging, the CHRG1 pin is pulled low by an internal N-channel MOSFET. When the charge cycle is completed, high impedance is forced to the CHRG1 and CHRG2 (pin 6) is pulled low, indicating an “AC present” condition.

Table1. Charge Status Summary

Condition	LED1	LED2
Battery charging	ON	OFF
Charge complete	OFF	ON

Block Diagram



Application Information

The HX6009G is a single cell lithium-ion battery charger using a constant-current/constant-voltage algorithm. It can deliver up to 900mA of charge current (using a good thermal PCB layout) with a final float voltage accuracy of ±1%. No blocking diode or external current sense resistor is required; thus, the basic charger circuit requires only few external components. Furthermore, the HX6009G is capable of operating from a USB power source.

Normal Charge Cycle

A charge cycle begins when the voltage at the Vcc pin rises above 4.5V and a 1% program resistor is connected from the PROG pin to ground or when a battery is connected to the charger output. If the BAT pin is less than 2.8V, the charger enters trickle charge mode.

In this mode, the HX6009G supplies approximately 1/10 the programmed charge current to bring the battery voltage up to a safe level for full current charging. When the BAT pin voltage rises above 2.8V, 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 (4.22V), the HX6009G enters constant-voltage mode and the charge current begins to decrease. The charge cycle ends when the charge current drops to zero.

Charge Termination

A charge cycle is terminated when the charge current falls to 1/10th the programmed value after the final float voltage is reached. This condition is detected by using an internal, filtered comparator to monitor the PROG pin.

When charging, transient loads on the BAT pin can cause the PROG pin to fall below 100mV for short periods of time before the DC charge current has dropped to 1/10th the programmed value. Once the average charge current drops below 1/10th the programmed value, the HX6009G terminates the charge cycle and ceases to provide any current through the BAT pin. In this state, all loads on the BAT pin must be supplied by the battery.

The HX6009G constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the recharge threshold (V_{RECHRG}), another charge cycle begins and current is once again supplied to the battery. To manually restart a charge cycle in standby mode, the input voltage must be removed and reapplied, or the charger must be shut down and restarted using the PROG pin.

Shutdown Mode

The HX6009G can be shut down by floating PROG pin. In shutdown mode, the battery drain current is reduced to 13μA and the supply current to about 80μA. A new charge cycle can be initiated by reconnecting the program resistor. Removing the input power supply will put the charger into sleep mode.

Programming Charge Current

The charge current is programmed using a single resistor R_{PROG} from PROG pin to ground. The battery charge current is 900 times the current out of the PROG pin. The R_{PROG} and the charge current can be calculated as following equation:

$$R_{PROG}=1V/I_{BAT} \bullet 900,\ I_{BAT}=1V/R_{PROG} \bullet 900.$$

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

$$I_{BAT}= R_{PROG}/R_{PROG} \bullet 900.$$

Thermal Limiting

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 120℃. This feature protects the HX6009G 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 HX6009G. 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. Thin SOT power considerations are discussed further in the Applications Information section.

Automatic Recharge

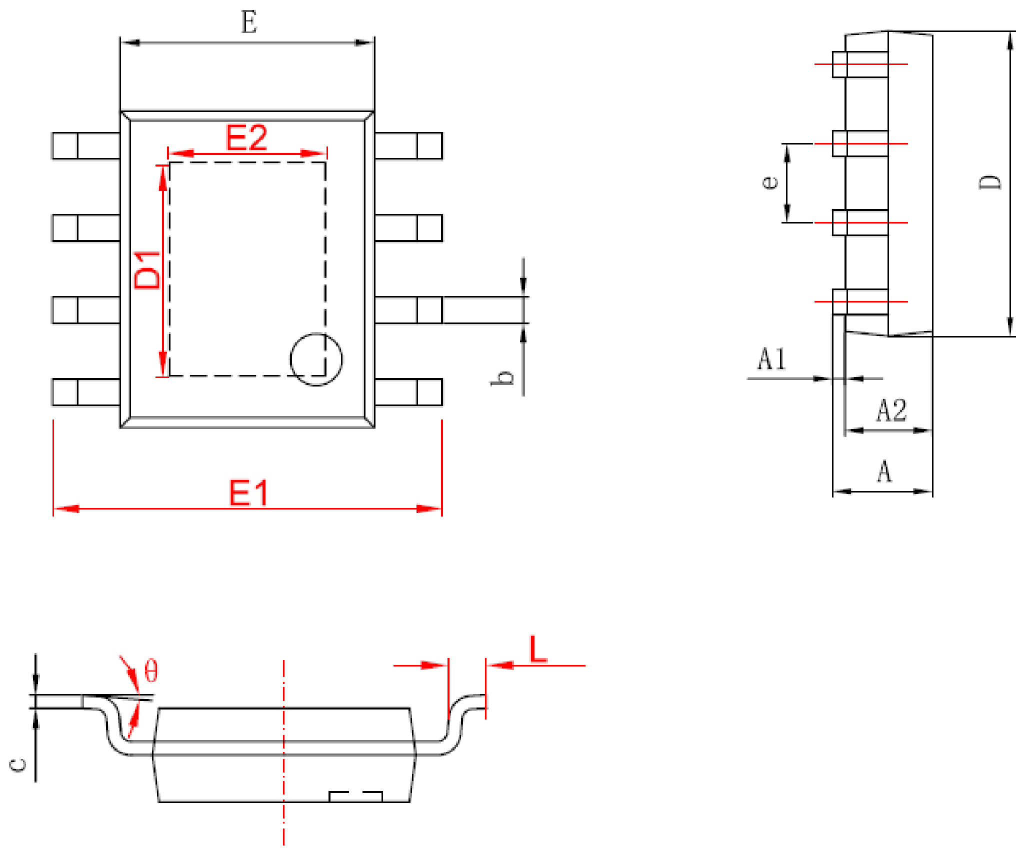
A charge cycle restarts when the battery voltage falls the recharge voltage (which corresponds to approximately 80% to 90% battery capacity). This ensures that the battery is kept at or near a fully charged condition and eliminates the need for periodic charge cycle initiations.

VCC 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 1.5W resistor in series with an X5R ceramic capacitor will minimize start-up voltage transients.

Packaging Information

SOP8-PP (EXP PAD) Package Outline Dimension



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.150	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
D1	3.202	3.402	0.126	0.134
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
E2	2.313	2.513	0.091	0.099
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.