Standalone Linear Li-Lon Battery Charger with Thermal Regulation

Features

- Programmable Charge Current Up to 800mA
- No MOSFET, Sense Resistor or Blocking Diode Required
- Complete Linear Charger for Single Cell Lithium-Ion Batteries
- Constant-Current/Constant-Voltage Operation with Thermal Regulation* to Maximize Charge Rate
- Without Risk of Overheating
- Charges Single Cell Li-Ion Batteries Directly from USB Port
- Preset 4.2V Charge Voltage with 1% Accuracy
- Automatic Recharge
- 65uA Supply Current in Shutdown
- 2.9V Trickle Charge Threshold
- Available in 5-Lead SOT-23 Package

Applications

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

Description

The CX9058 is a complete constant-current/ constant voltage linear charger for single cell lithium-ion batteries. Its package and low e xternal component count make the CX9058 i deally suited for portable applications. Furthe rmore, the CX9058 is specifically designed t o 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. The CX9058 automatically terminates the charge cycle when the charge current drops to 1/10th the programmed value after the final float voltage is reached.

The CX9058 converters are available in the industry standard SOT-23-5 power packages (or upon request).

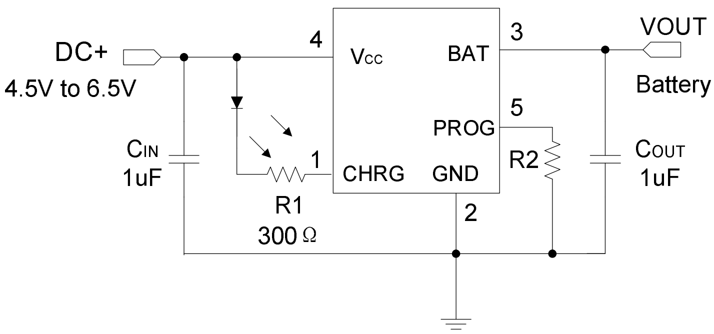
Order Information

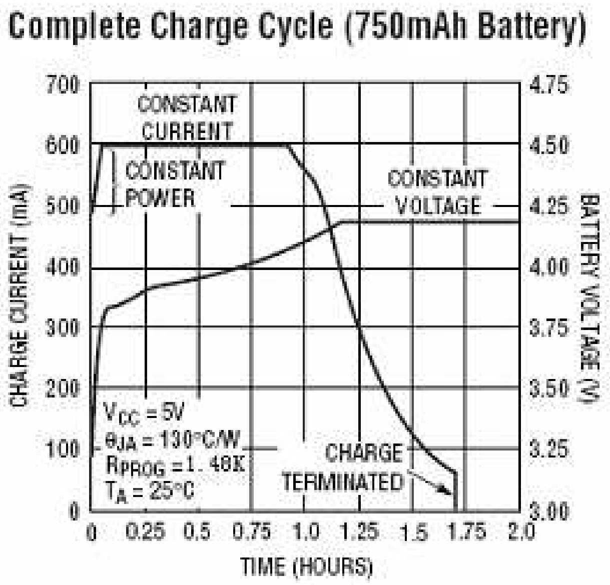
CX9058 - ① ②:

SYMBOL	DESCRIPTION
①	Denotes Output voltage: 4.2V
②	Denotes Package Types: E: SOT-23-5

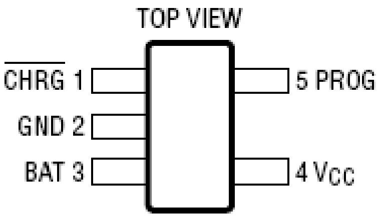
Typical Application

600mA Single Cell Li-Lon Charger





Pin Assignment



S5 PACKAGE
5-LEAD PLASTIC TSOT-23

PIN NUMBER SOT-23- 5	PIN NAME	FUNCTION
1	CHRG	Open-Drain Charge Status Output
2	GND	Ground
3	BAT	Charge Current Output
4	V_{CC}	Positive Input Supply Voltage.
5	PROG	Charge Current Program, Charge Current Monitor and Shutdown Pin

Absolute Maximum Ratings

- Input Supply Voltage (VCC) .... –0.3V to 7V
- PROG.. – 0.3V to VCC + 0.3V
- BAT .... –0.3V to 7V
- CHRG.. –0.3V to 7V
- BAT Short-Circuit Duration .... Continuous
- BAT Pin Current 800mA
- Maximum Junction Temperature .... 125℃
- Operating Ambient Temperature Range.. –40℃ to 85℃
- Storage Temperature Range ………………………………………….................. –65 ℃to 125℃
- Lead Temperature (Soldering, 10 sec).. 300℃

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_{CC}	Input Supply Current	Charge Mode , R_{PROG} = 10k Standby Mode (Charge Terminated) I Shutdown Mode (R_{PROG} Not Connected, V_{CC} < V_{BAT}, or V_{CC} < VUV)		70 45 65		μA μA μA
V_{FLOAT}	Regulated Output (Float) Voltage	0℃≤T_A≤85℃, I_{BAT} = 50mA	4.15	4.2	4.24	V
I_{BAT}	BAT Pin Current	R_{PROG} = 10k, Current Mode R_{PROG} = 2k, Current Mode Standby Mode, V_{BAT} = 4.2V Shutdown Mode (R_{PROG} Not Connected) Sleep Mode, V_{CC} = 0V	83 410	89 445 7.3 7.2 0.3	97 470 15 1	mA mA μA μA μA
I_{TRIKL}	Trickle Charge Current	V_{BAT} < V_{TRIKL}, R_{PROG} = 2k	15	39	65	mA
V_{ASD}	V_{CC} – V_{BAT} Lockout Threshold Voltage	V_{CC} from Low to High V_{CC} from High to Low		5 18		mV
I_{TERM}	C/10 Termination Current Threshold	R_{PROG} = 2k		45		mA
V_{PROG}	PROG Pin Voltage	R_{PROG} = 10k, Current Mode	0.94	1.02	1.08	V
R_{ON}	Efficiency	Power FET "ON" Resistance (Between VCC and BAT)		660		mΩ

Application Information

PIN ASSIGNMENT

CHRG (Pin 1): Open-Drain Charge Status Output. When the battery is charging, the CHRG pin is pulled low by an internal N-channel MOSFET. When the charge cycle is completed or reverse battery lockout / No AC is detected, CHRG is forced high impedance.

GND (Pin 2): Ground.

BAT (Pin 3): Charge Current Output. It should be bypassed with at least a 1uF capacitor. It Provides charge current to the battery and regulates the final float voltage to 4.2V. An internal precision resistor divider from this pin sets the float voltage which is disconnected in shutdown mode.

VCC (Pin 4): Positive Input Supply Voltage. It Provides power to the charger VCC can range from 4.30V to 6.5V and should be bypassed with at least a 1uF capacitor. When VCC drops to within 20mV of the BAT pin voltage, the CX9058 enters shutdown mode, dropping IBAT to less than 1 uA.

PROG (Pin 5): Charge Current Program, Charge Current Monitor and Shutdown Pin. The charge current is programmed by connecting a 1% resistor, RPROG, 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: IBAT = (VPROG/RPROG)*890, The PROG pin can also be used to shut down the charger. Disconnecting the program resistor from ground allows a weak current to pull the PROG pin high. When it reaches the 1.21V shutdown threshold voltage, the charger enters shutdown mode, charging stops and the input supply current drops to 65uA. Reconnecting RPROG to ground will return the charger to .normal operation.

Operation

The CX9058 is a single cell lithium-ion battery charger using a constant-current/constant-voltage algorithm. It can deliver up to 800mA of charge current (using a good thermal PCB layout) with a final float voltage accuracy of ±1%. The CX9058 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 two external components. Furthermore, the CX9058 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 the UVLO threshold level 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 2.9V, the charger enters trickle charge mode.

In this mode, the CX9058 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 2.9V, 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 CX9058 enters constant-voltage mode and the charge current begins to decrease. When the charge current drops to 1/10 of the programmed value, the charge cycle ends.

Programming Charge Current

The charge current is programmed using a single resistor from the PROG pin to ground. The battery charge current is 1000 times the current out of the PROG pin. The program resistor and the charge current are calculated using the following equations:

$$R_{PROG} = \frac{1000V}{I_{CHG}}, \quad I_{CHG} = \frac{1000V}{R_{PROG}}$$

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

$$I_{BAT} = \frac{V_{PROG}}{R_{PROG}} \bullet 1000$$

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 the PROG pin voltage falls below 100mV1 for longer than t_{TERM} (typically 1ms), charging is terminated. The charge current is latched off and the CX9058 enters standby mode, where the input supply current drops to 200mA. (Note: C/10 termination is disabled in trickle charging and thermal limiting modes).

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. The 1ms filter time (tTERM) on the termination comparator ensures that transient loads of this nature do not result in premature charge cycle termination.

Once the average charge current drops below 1/10th the programmed value, the CX9058 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 CX9058 constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the 4.05V recharge threshold (VRECHRG), another charge cycle begins and current is once again supplied to the battery. To manually restart a charge cycle when in standby mode, the input voltage must be removed and reapplied, or the charger must be shut down and restarted using the PROG pin. Figure 1 shows the state diagram of a typical charge cycle.

Charge Status Indicator (CHRG)

The charge status output has three different states: strong pull-down (~10mA), weak pull-down (~20mA) and high impedance. The strong pull-down state indicates that the

CX9058 is in a charge cycle. Once the charge cycle has termi nated, the pin state is determined by undervoltage lockout conditions. A weak pull-down indicates that VCC meets the UVLO conditions and the CX9058 is ready to charge. High impedance indicate s that the CX9058 is in undervoltage lockout mode: either VCC is less than 100mV above the BAT pin voltage or insufficient voltage is applied to the VCC pin. A microprocessor can be used to distinguish between these three states—this method is discussed in the Applications Information section.

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° C. This feature protects the CX9058 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 CX9058. Th e 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. ThinSOT power considerations are discussed further in the Applications Information section.

Undervoltage Lockout (UVLO)

An internal undervoltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until VCC rises above the undervoltage lockout threshold. The UVLO circuit has a built-in hysteresis of 200mV. Furthermore, to protect against reverse current in the power MOSFET, the

UVLO circuit keeps the charger in shutdown mode if VCC falls to within 30mV of the battery voltage. If the UVLO comparator is tripped, the charger will not come out of shutdown mode until VCC rises 100mV above the battery voltage.

Manual Shutdown

At any point in the charge cycle, the CX9058 can be putinto shutdown mode by removing RPROG thus floating the PROG pin. This reduces the battery drain current to less than 2mA and the supply current to less than 50mA. A new charge cycle can be initiated by reconnecting the program resistor.

In manual shutdown, the CHRG pin is in a weak pull-down state as long as VCC is high enough to exceed the UVLO conditions. The CHRG pin is in a high impedance state if the CX9058 is in undervoltage lockout mode: either VCC is within 100mV of the BAT pin voltage or insufficient voltage is applied to the VCC pin.

Automatic Recharge

Once the charge cycle is terminated, the CX9058 continuously monitors the voltage on the BAT pin using a comparator with a 2ms filter time ($t_{RECHARGE}$). A charge cycle restarts when the battery voltage falls below 4.05V (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. CHRG output enters a strong pull down state during recharge cycles.

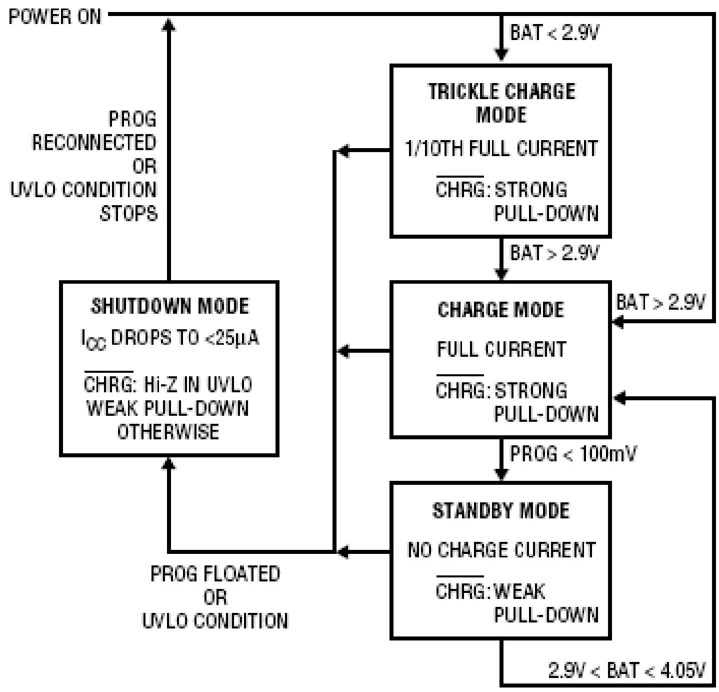


Figure 1. State Diagram of a Typical Charge Cycle

V_{CC} Bypass Capacitor

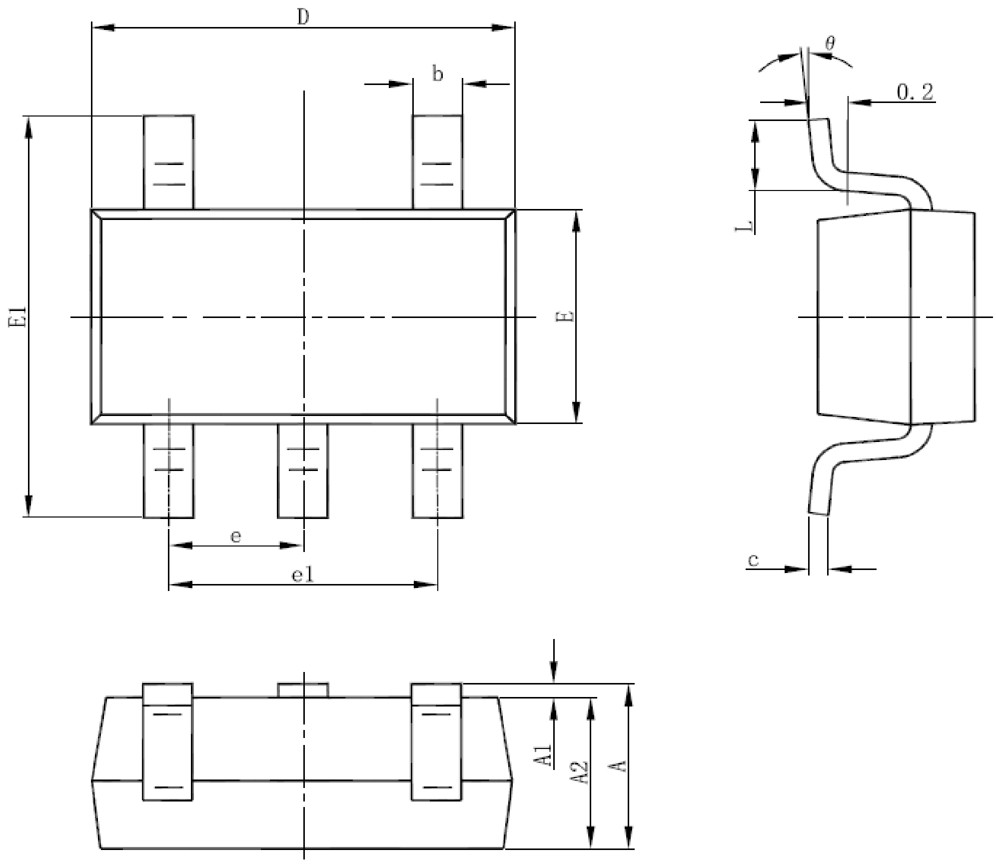
Many types of capacitors can be used for input bypassing, however, caution must be exercised when using multilayer ceramic capacitors. Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, high voltage transients can be generated under some start-up conditions, 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.

Charge Current Soft-Start

The CX9058 includes a soft-start circuit to minimize the inrush current at the start of a charge cycle. When a charge cycle is initiated, the charge current ramps from zero to the full-scale current over a period of approximately 100ms. This has the effect of minimizing the transient current load on the power supply during start-up.

Packaging Information

SOT-23-5 Package Outline Dimension



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024