500mA linear li-Ion battery charger

Descriptions

- The SL4057 is a high performance constant current/voltage linear charger for single-cell Li-Ion batteries.The SL4057 is available in a SOT23-6 package with fewer peripheral components, which makes it ideal for portable products and suitable for powering USB power supplies as well as adapter power supplies.

- Based on a special internal MOSFET architecture and an anti-reverse charge circuit, the SL4057 does not require external detection resistors and isolation diodes. Thermal feedback regulates the charging current to reduce the chip temperature when the ambient temperature is too high or in high power applications. The charging voltage is fixed at 4.24V, while the charging current can be set externally via a resistor. When the charge current drops to 1/10 of the set value after reaching the final float voltage, the chip will terminate the charge cycle.

- When the input voltage is disconnected, the SL4057 goes to sleep and the battery leakage current drops below 1uA, the SL4057 can be set to shutdown mode where the quiescent current drops to 25uA.

- The SL4057 also includes other features: undervoltage lockout, automatic recharge, and two status pins to indicate charging and charge termination.

Features

- Programmable charging current 500ma
- No external mosfets, detection resistors and isolation diodes required
- Complete linear charger for single cell li-ion batteries in sot23-6 package
- Constant current/constant voltage operation with thermal regulation to maximize charge rate without risk of overheating.
- 4.24v pre-charge voltage with ±1% accuracy
- Charge current monitor output for battery level detection
- Automatic re-charging
- Charge status dual output, no battery and fault status indication
- C/10 charge termination
- 25ua quiescent current in standby mode
- 2.9v trickle charge
- Soft start limits inrush current
- Battery reverse connection protection
- Battery undervoltage protection activates charging
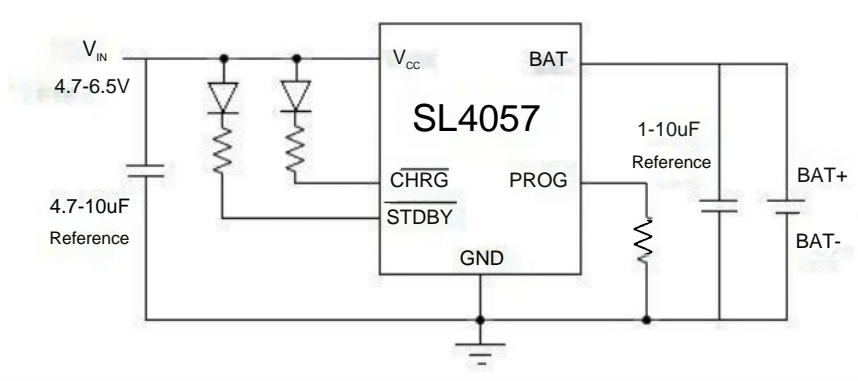
Applications

- Cell phones, PDA
- Mp3, mp4 players
- Battery level
- Digital camera
- Electronic dictionary
- Bluetooth, GPS navigator
- Portable equipment
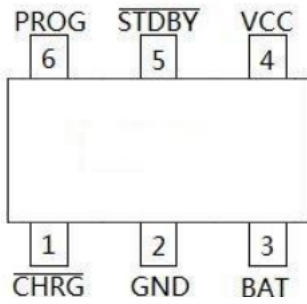
SL4057 In SOT23-6 Package
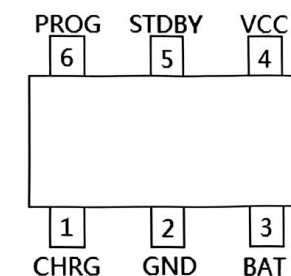
Typical application

Pin configuration and function

SOT23-6

Pin function

| Pin Number	Pin Name	Description
1	CHRG	battery charge indicator
2	GND	ground
3	BAT	battery side
4	VCC	power supplyside
5	STDBY	battery charging completion indicator
6	PROG	programmable constant current charge current setting terminal

Maximum Ratings

Parameters	Value	Unit
VCC terminal voltage	-0.3 to 6.5	V
PROG terminal voltage	-0.3 to 6.5	V
BAT terminal voltage	-0.3 to 6.5	V
CHRG terminal voltage	-0.3 to 8	V
STDBY terminal voltage	-0.3 to 8	V
current at BAT	500 mA	mA
PROG terminal current	800 uA	uA
maximum power consumption	400	mW
	800 (Increase PCB heat dissipation)[1]	
operating Temperature	-40 ~ 85	°C
minimum/maximum storage temperature $_{Tstg}$	-65 to 125	°C

Note：Increase PCB heat dissipation parameters are for reference only, subject to actual conditions

ESD and Latch-up Ratings

mannequin ESD level	4000V
machine Model ESD Levels	400 V
latch-up level	400mA

Structural block diagram
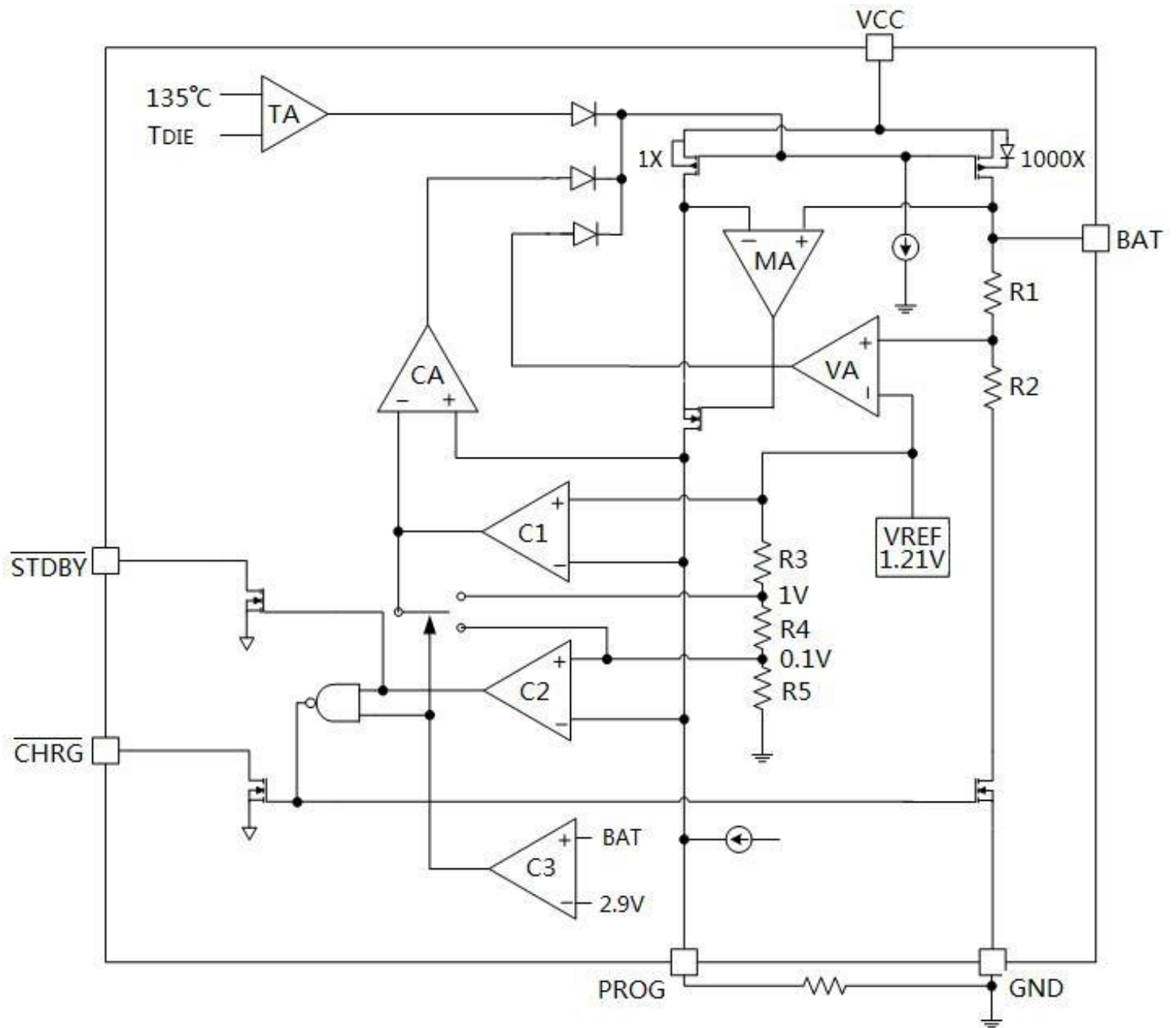
Electrical Characteristics (If not specified, ambient temperature = 25℃, input voltage = 5V)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
V_{CC}	Input supply voltage		4		6.5	V
I_{CC}	Input power supply current	charging mode(RPROG=10K) (1)		240	500	uA
		standby mode (charge termination)		45	90	uA
		Stop mode (RPROG is not connected. V_{CC}<V_{BAT}, V_{CC}<V_{UVLO})		25	50	uA
V_{FLOAT}	Output float voltage	0°C≤T≤85°C，I_{BAT}=40mA	4.198	4.24	4.282	V
I_{BAT}	Charging current at BAT side	constant current mode，RPROG=10K	93	100	107	mA
		constant current mode，RPROG=2K	465	500	535	mA
		standby mode，V_{BAT}=4.2V	0	-2.5	-6	uA
		shutdown mode		1	2	uA
		battery reverse mode，V_{BAT}=-4V		0.7		mA
		sleep mode，V_{CC}=0V		0	1	uA
I_{TRIKL}	Trickle charge current	V_{BAT}＜V_{TRIKL}, RPROG=2K	40	50	60	mA
V_{TRIKL}	Trickle charge threshold voltage	V_{BAT} rising	2.7	2.9	3.1	V
V_{TRHYS}	Trickle charge hysteresis voltage	V_{BAT} falling	60	80	100	mV
V_{UVLO}	V_{CC} undervoltage lockout voltage	V_{CC} rising	3.6	3.8	4	V
V_{UVHYS}	V_{CC} undervoltage lockout hysteresis voltage	V_{CC} falling	150	200	300	mV
V_{MSD}	manual shutdown threshold voltage	V_{PROG} rising	1.15	1.21	1.3	V
		V_{PROG} falling	0.9	1	1.1	V
V_{ASD}	V_{CC} -V_{BAT} lockout voltage	V_{CC} rising	70	100	140	mV
		V_{CC} falling	5	30	50	mV
I_{TERM}	C/10 termination current threshold[2]	RPROG=10K	0.085	0.1	0.115	mA/mA
		RPROG=2K	0.085	0.1	0.115	mA/mA
V_{PROG}	PROG pin voltage	constant current mode，RPROG=10K	0.93	1	1.07	V
V_{CHRG}	CHRG terminal outputs a low level	I_{CHRG}=5mA		0.35	0.6	V
V_{STDBY}	STDBY terminal outputs low level	I_{STDBY}=5mA		0.35	0.6	V
V_{RECHG}	rechargeable Battery Threshold Voltage	V_{FLOAT}-V_{RECHG}		100	200	mV
t_{RECHG}	recharge delay time	V_{BAT} from high to low	0.8	1.8	4	ms
t_{TERM}	charge termination delay time	I_{BAT} falls below I_{CHG}/10	0.63	1.4	3	ms
I_{PROG}	pull-up current at PROG			2		uA

Note
- This is the charging state, I_{CC}= I_{VCC}- I_{BAT}
- Here C/10 termination current threshold refers to the ratio of the termination current to the constant current charging current

Instructions for use

The SL4057 is a linear charger designed specifically for Li-ion batteries, using the internal power MOSFETs to charge the battery at constant current/voltage. The charging current can be programmed by an external resistor, and the maximum charging current can be up to 500mA. SL4057 has two open drain outputs, the charging status indicator CHRG and the battery charging completion indicator STDBY. The power tube circuit inside the chip automatically reduces the charging current when the junction temperature of the chip exceeds 135℃, which enables the user to make maximum use of the chip for charging without worrying about the chip overheating and damaging the chip. This function allows users to maximise the use of the chip charging without worrying about the chip overheating and damaging the chip or external components.

How it works

The SL4057 starts charging the battery when the input voltage is greater than the UVLO detection threshold and the chip enable input goes high. If the battery voltage is lower than 2.9V, the charger pre-charges the battery with low current. When the battery voltage exceeds 2.9V, the charger uses constant current mode to charge the battery, and the charging current is determined by the resistance between the PROG terminal and the GND terminal. When the battery voltage is close to 4.24V, the charging current decreases gradually and the SL4057 enters the constant voltage charging mode. When the charging current decreases to the end-of-charge threshold, the charging cycle ends.

The end-of-charge threshold is 1/10 of the constant-current charging current, and when the battery voltage drops below the re-charge threshold, a new charging cycle starts automatically. The high precision voltage reference, error amplifier and resistor divider network ensure that the modulating voltage at the BAT terminal is within 1% accuracy, which meets the requirements of Li-ion and Li-polymer batteries. When the input voltage drops out or the input voltage is lower than the battery voltage, the charger enters the shutdown mode and the current consumption at the battery side is less than 2uA, thus increasing the standby time.

Charging current setting

The charging current is set using a resistor connected between the PROG pin and ground. The current charging current is 1000 times the output current of the PROG pin. The following formula is used to set the resistor and charge current:

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

The charging current output from the BAT pin can be readily determined by monitoring the PROG pin voltage with the following formula:

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

The relationship between RPROG and charging current is determined in the table below:

RPROG (K)	I$_{BAT}$ (mA)
2	500
2.2	400
3	300
5	200

Charge termination

The charging cycle is terminated when the charging current drops to 1/10 of the set value after the final float voltage is reached. This condition is detected by monitoring the PROG terminal using an internal filter comparator. When the voltage at the PROG terminal drops below 100mV for more than 1.8ms, charging is terminated and the SL4057 enters standby mode where the input supply current drops to approximately 45uA.

During charging, a transient load on the BAT terminal will cause the voltage at the PROG terminal to drop below 100mV briefly between the time the DC charging current drops to 1/10th of the set value, the comparator's 1.8ms delay time ensures that transient loads of this nature do not cause the charging cycle to terminate prematurely. Once the average charge current drops below 1/10th of the set value, the SL4057 centralised charge cycle stops supplying any current through the BAT terminal. In this state, all loads on the BAT terminal must be powered by the battery.

Charging status indication

The SL4057 has two open drain status indication outputs, CHRG and STDBY. CHRG is pulled low when the charger is in the charging state, and in other states CHRG is in the high resistance state; STDBY is pulled low when the battery is finished charging, and in other states STDBY is in the high resistance state.

When the battery is not connected to the charger, CHRG flashes to indicate that no battery is installed.

State Of Charge	CHRG	STDBY
Charging.	clear	go out
Charging complete	go out	clear
1uF capacitor connected to BAT terminal, no battery	flashing (frequency approx. 20Hz)	clear

Thermal limitations

If the chip temperature rises above 135 C, an internal thermal feedback loop will reduce the set charge current. This feature prevents the SL4057 from overheating and allows the user to increase the upper limit of a given board's power handling capability while reducing the risk of damaging the SL4057.

Undervoltage lockout

The SL4057 has an internal undervoltage lockout circuit that monitors the input voltage and keeps the chip in shutdown mode until VCC rises to the undervoltage lockout threshold voltage. When VCC rises to 3.8V, the chip exits UVLO and begins normal operation, with a UVLO hysteresis voltage of 200mV when VCC falls.

Automatic charging cycle

After the battery voltage reaches the float voltage and the charging cycle is terminated, the SL4057 immediately monitors the voltage at the BAT terminal. When the BAT voltage falls below 4.1V, the charging cycle is restarted.This ensures that the battery is maintained at a nearly fully charged state and eliminates the need for periodic charging cycle starts.

Package:

SOT23-6
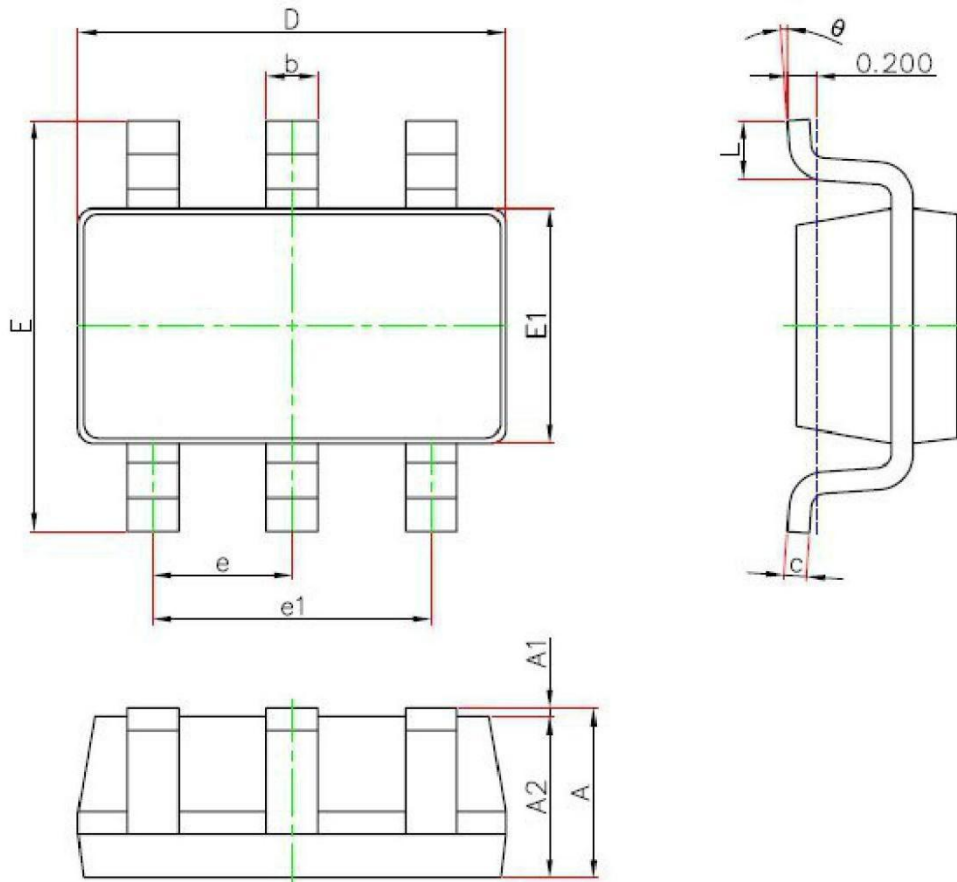
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E1	1.500	1.700	0.059	0.067
E	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°