Advanced Lithium-Ion Linear Battery Charger

General Description

SL1053 is a single Lithium-Ion or Lithium-Polymer cell linear battery charger which is designed for compact and cost-sensitive handheld devices. It combines charge status indication, charge termination, battery temperature monitoring, and high accuracy current and voltage regulation in a SOP-8 package.

SL1053 charges the battery in three modes, precharge, constant current, constant voltage. If the battery voltage is below the precharge threshold VO(MIN), the SL1053 precharges the battery with a lower conditioning current. After precharge, the SL1053 applies a constant current to the battery. An external sense-resister sets the charge current. The constant voltage mode continues until the battery reaches the regulation

The battery temperature is continuously measured by an external thermistor through the TS pin. SL1053 inhibits charge until the temperature is within the range defined by users.

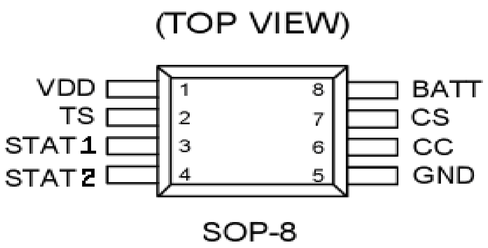
Features

- For Single Lithium-Ion or Lithium-Polymer Cell Battery Pack 4.2V
- A Few External Components are Required
- Precharge, Constant Current, Constant Voltage Modes
- Battery Temperature Monitor
- Charge Status Indication
- Automatic Battery Recharge
- Charge Termination Detect
- Auto Low Power Sleep Mode when VDD Power is removed
- MSOP-8 Package
- RoHS Compliant and 100% Lead (Pb)-Free

Applications

- Digital Cameras
- PDAs
- Cellular Phones
- Information Appliance

Pin Configurations



Typical Application Circuit

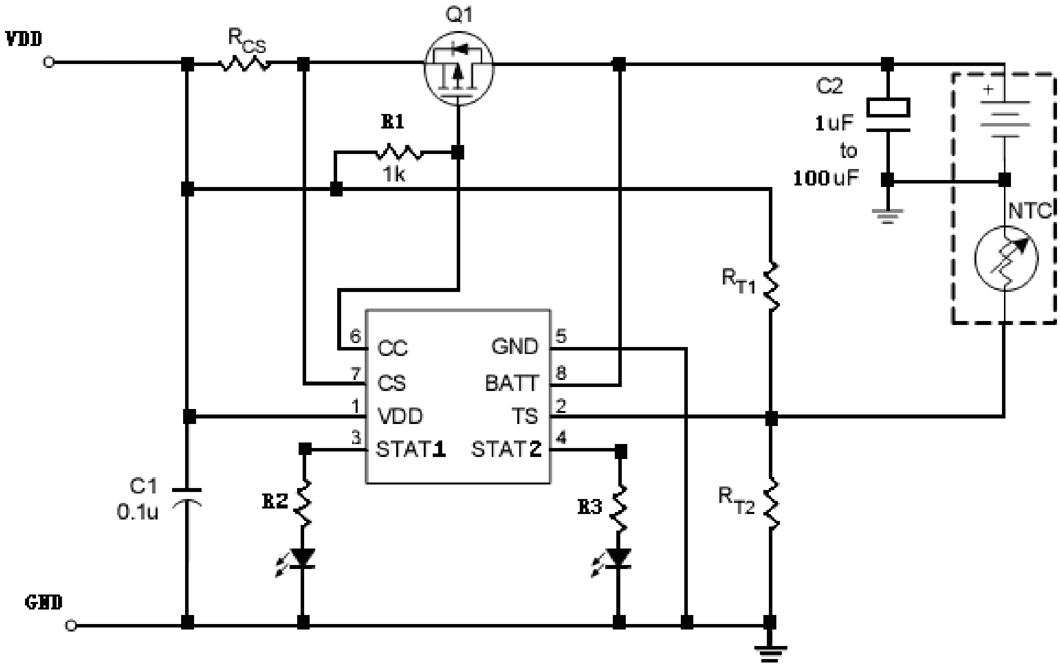


Figure1: Application circuit using P-channel MOSFET

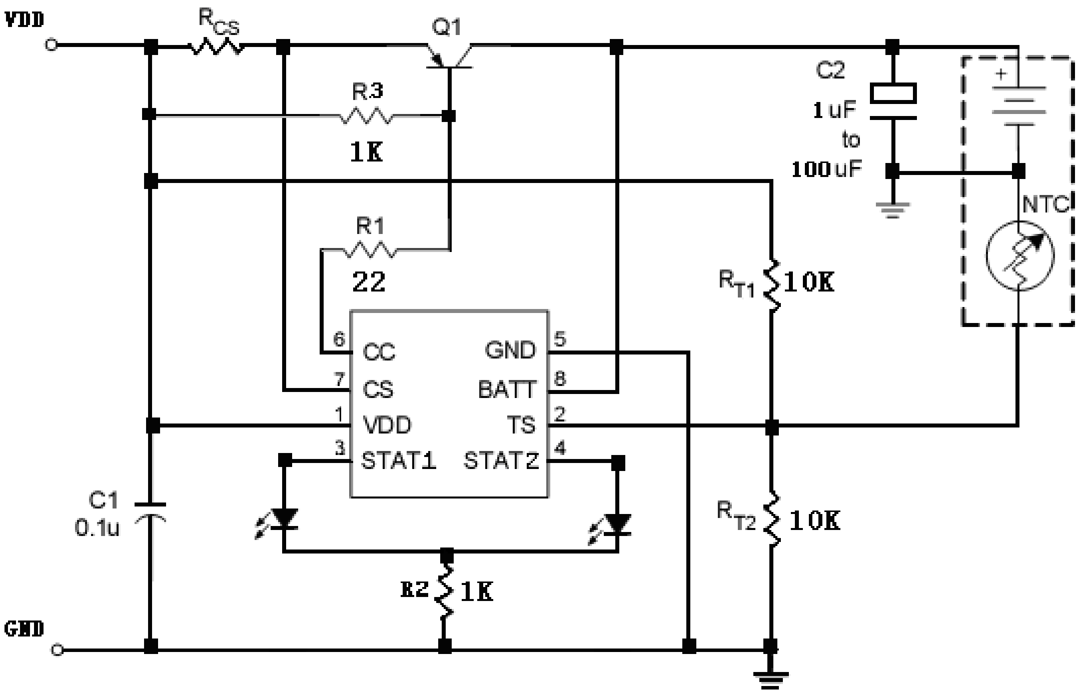


Figure2: Application circuit using PNP transistor

Founctinal Pin Description

Pin Name	Pin Funtion
VDD	Supply Voltage Input
TS	Temperature Sense Input. Input from battery temperature monitoring circuit.
STAT1	In charge status, this pin is pulled to high; when charge completed, it's pulled to low; and if temperature fault or disable, it's in high impedance status.
STAT2	In charge status, this pin is pulled to low; when charge completed, it's pulled to high; and if temperature fault or disable, it's in high impedance status.
GND	Gound
CC	Charge Control Output. Current output to drive on external PNP transistor or P-Channel MOSFET for current and voltage regulation
CS	Current Sense Input. Charge current is sensed according to the voltage drop from supply voltage to this pin
BATT	Battery voltage input. Input directly from battery voltage.

Absolut Maxmum Ratings(Note 1)

- Supply Voltage -- −0.3V～7V
- Storage Temperature Range------------------------------------−65℃～150℃
- Power Dissipation, PD@T_A=25℃------------------------------------ 300mW
- Junction Temperature --- 150℃
- Operation Juntion Temperature Range------------------------- −40℃～+125℃
- ESD Susceptibility (Note2)--- 4KV

Recommneded Operation Conditions(Note 3)

- Supply Input Voltage---4.5V to 7V
- Junction Temperature Range----------------------------------- −20℃～+70℃

Electrical Characteristics(T_A=25℃)

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Operating Current	$I_{DD(OPE)}$	$4.5V<V_{DD}<7V$	----	1	2	mA
Vdd Sleep Current	$I_{DD(sleep)}$	$V_{BATT}-V_{DD}\geq 0.2V$	----	----	3	uA
Input Bias Current @ BATT Pin	I_{BATT}	$V_{BATT}=V_{O(REG)}$, $V_{BATT}-V_{DD}\geq 0.2V$	----	1.5	2.6	uA
Input Bias	I_{TS}	V_{TS} =5V,	----	----	1.1	uA

Current @ TS Pin		$V_{BATT}-V_{DD} \geq 0.2V$				
Input Bias Current @ CS Pin	I_{CS}	V_{CS} =5V, $V_{BATT}-V_{DD} \geq 0.2V$	---	---	1.1	uA
Output Voltage	$V_{O(REG)}$		4.160	4.20	4.240	V
Current Regulation Threshold	$V_{I(SNS)}$	$V_{I(SNS)}=V_{DD}-V_{CS}$	100	115	130	mV
Current Detect Threshold	$V_{(PRE)}$	$V_{(PRE)}=V_{DD}-V_{CS}$	4	12	24	mV
Precharge Threshold	$V_{O(MIN)}$		2.7	2.9	3.1	V
Recharge Threshold	$V_{O(RCH)}$		$V_{O(REG)}$-170mV	$V_{O(REG)}$-110mV	$V_{O(REG)}$-50mV	V
Charge Teminated Current Detect Threshold	$V_{(TERM)}$	$V_{(TERM)}=V_{DD}-V_{CS}$	2	12	22	mV
Ouput Low Voltage @STAT1Pin	$V_{STAT1(LOW)}$	I_{OL} =10mA	-----	0.4	0.6	V
Ouput High Voltage @STAT1Pin	$V_{STAT1(HIGH)}$	I_{OH}=5mA	V_{DD}-0.5V	----	----	V
Ouput Low Voltage @STAT2 Pin	$V_{STAT2(LOW)}$	I_{OL} =10mA	-----	0.4	0.6	V
Ouput High Voltage @STAT2 Pin	$V_{STAT2(HIGH)}$	I_{OH}=5mA	V_{DD}-0.5V	----	----	V
Lower Temperature Threshold	V_{TS1}*		28	30	32	%V_{DD}
Upper Temperature Threshold	V_{TS2}*		68	70	72	%V_{DD}

Note 1. Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. 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 remain possibility to affect device reliability.

Note 2. Devices are ESD sensitive. Handling precaution recommended.

Note 3. The device is not guaranteed to function outside its operating conditions.

Application Information

Charge Profile

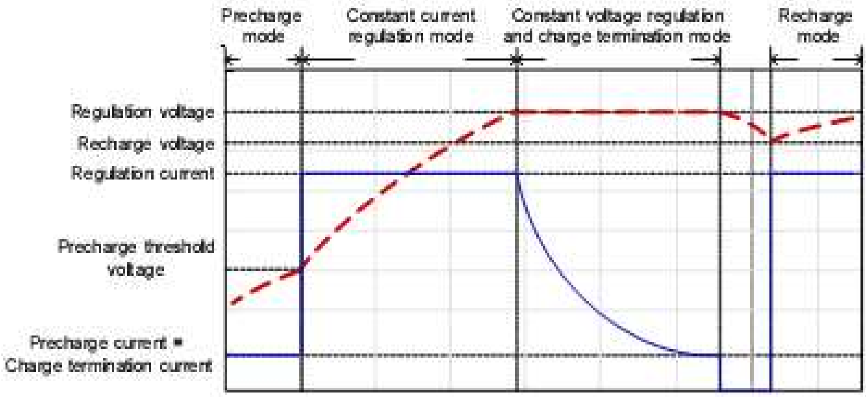


Figure 3. Typical charge profile

Detection

First, the FB/CE pin must connect to VDD or a voltage divider to enable the charge function. And then if a battery is already inserted and the input power source is absent, the SL1053 will enter sleep mode to prevent draining power from battery. When input power source and battery are both existed, another detection is the battery temperature. The TS pin voltage must be in the allowed range as shown in Figure 6 and the electrical characteristics, and then the SL1053 will start the charge cycle according to the battery voltage conditions.

Precharge Mode

When the battery voltage is lower than the precharge threshold VO(MIN), the SL1053 begins to charge the battery in precharge mode. In this condition, the precharge current is set at approximately 10% of the constant regulation current. The purposes of small precharge current are to minimize the power dissipation on the external switch during the precharge period and to revive deeply discharged battery cells.

Constant Current Regulation Charge Mode

When the battery voltage is between the precharge threshold VO(MIN) and the regulation voltage VO(REG), the SL1053 starts the constant current regulation charge mode. SL1053 monitors charge current with voltage drop between two terminals of a sense-resistor, RCS, which connects to pin VDD and CS. The following equation can calculate the desired charging current.

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

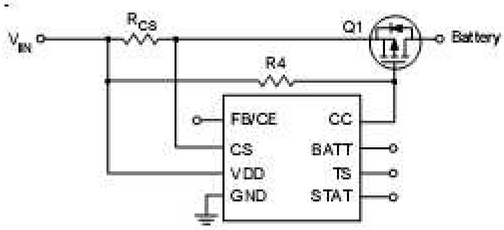


Figure 4

Constant Voltage Regulation and Charge Termination Mode

When the battery voltage reaches the regulation voltage VO(REG), the constant voltage feedback control starts, and then the charge current begins to decrease as the typical charge profile shown. As the charge current decreases to lower than charge terminated current threshold, the SL1053 will terminate the charge cycle.

Recharge Mode

After the charge termination mode, if the battery voltage falls to lower than the recharge threshold voltage VO(RCH), the SL1053 will begin a new charge cycle according to the battery voltage.

Battery Temperature Detection

The SL1053 continuously detects the battery temperature by measuring the TS pin voltage. A NTC or PTC thermistor can parallel with RT2 to deviate the TS pin voltage. (As shown in Figure 5) The TS pin voltage must be within normal temperature voltage range that is shown in Figure 6 and electrical characteristics, and then SL1053 can start working normally.

The RT1 and RT2 can be derived from following equations.

For NTC Thermistors:

For NTC Thermistors:

$$R_{T1} = \frac{5 \times R_{TH} \times R_{TL}}{3 \times (R_{TL} - R_{TH})}$$

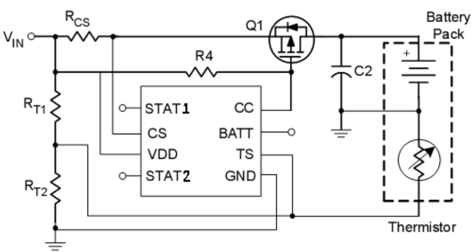
$$R_{T2} = \frac{5 \times R_{TH} \times R_{TL}}{[(2 \times R_{TL}) - (7 \times R_{TH})]}$$

For PTC Thermistors:

$$R_{T1} = \frac{5 \times R_{TH} \times R_{TL}}{3(R_{TH} - R_{TL})}$$

$$R_{T2} = \frac{5 \times R_{TH} \times R_{TL}}{[(2 \times R_{TH}) - (7 \times R_{TL})]}$$

Where RTL is the resistance value in lowest desired operation temperature and RTH is the resistance value in highest desired operation temperature. The resistances of thermistors are specified by the thermistor manufacturer. If the temperature monitoring function is not desired, there's an easy method to set RT1 and RT2 at the same value and disconnect the thermistor to disable this function.



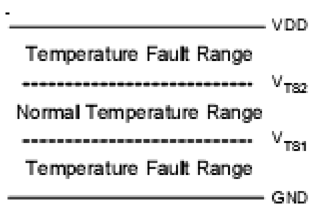


Figure 6

Charge status indication

The SL1053 indicates the status of the charger on the 3-state STAT1 and STAT2 pin. The following table shows the statuses of this pin.

Condition	STAT1 Pin	STAT2 Pin
In batter charging cycle	High	Low
Charge cycle completed	Low	High
Temperature fault or charge function disable or output shorted	High Impedance	High Impedance

Selecting an External PNP Pass-Transistor or P-Channel MOSFET:

The SL1053 drives an external PNP transistor or P-Channel MOSFET to control the charging current. The specifications must be concerned are the voltage and current rating and package power dissipation. The external switch is performed as a linear regulator. The maximum power loss occurs when the constant current regulation starts at the beginning, and it can be calculated approximately from following equation:

$$PD(MAX) = I(SNS) \times (VDD - 0.1V - 2.8V)$$

I(SNS) is the constant regulation current.

The minimum voltage drop between the sense-resistor is 100mV, and the minimum precharge threshold voltage is 2.8V.

The external pass device with PCB heatsinking must be rated for the maximum power dissipation.

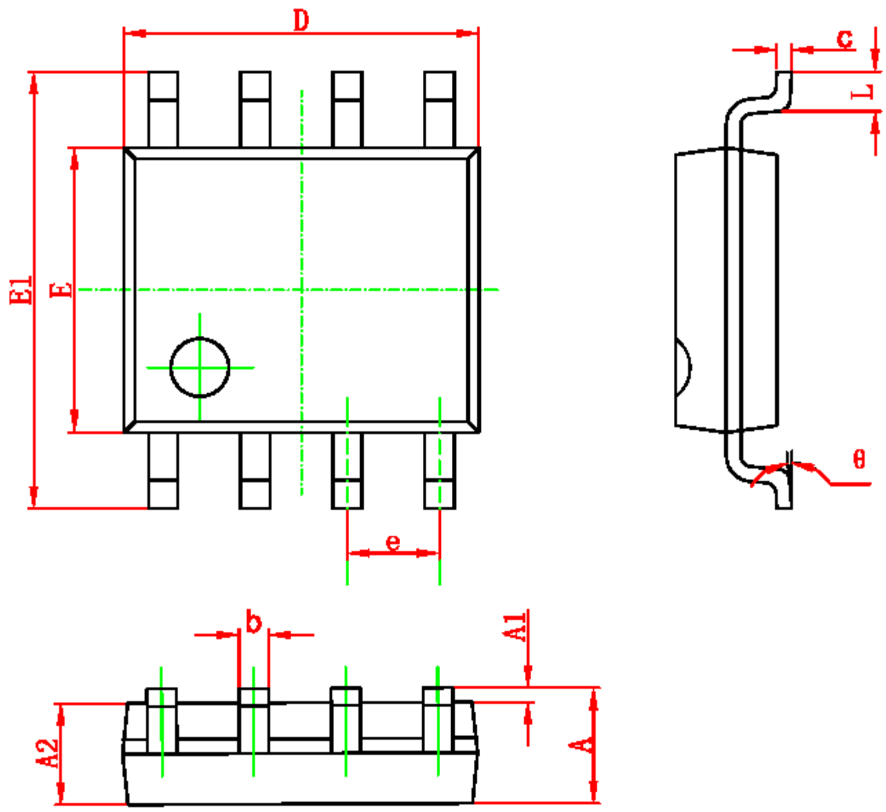
Selecting Input/Output Capacitor

In analog circuit applications, to place a high-frequency decoupling capacitor nearby the controller IC between input power source and ground is very important. A 0.1uF ceramic is recommended. If a high ripple and noise input power is chosen, it should have enough capacitance to reduce the disturbance.

A 0.1uF to 1uF output capacitor is recommended to control the output voltage and keep the output voltage ripple small when the battery is disconnected

.

SOP8 PACKAGE OUTLINE DIMENSIONS



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°