

南京拓品微电子有限公司

NanJing Top Power ASIC Corp.

数据手册

DATASHEET

**TP4083**

**(3mA-500mA Linear  
Li-Ion Battery Charger)**

## DESCRIPTION

The TP4083 is a complete linear charger for single cell lithium-ion batteries with OVP protection, with battery reverse connect protection and power supply reverse connect protection. The charge current can range from 3mA to 500mA. It includes trickle, constant-current and constant-voltage. The SOT23-6 or DFN2\*2-6 package and the small number of external components make the TP4083 ideal for portable applications. The TP4083 can work with USB power supplies and adapter power supplies.

The 16V overvoltage protection point makes the chip suitable for applications with a wider range of input voltage requirements. When the voltage of 6.5V~16V is input, the chip still has a certain output current to charge the battery, reducing the charging time. Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature. The TP4083 automatically terminates the charge cycle when the charge current drops to 1/10th the programmed value after the final float voltage reaching.

When the input supply (wall adapter or USB supply) is removed, the TP4083 automatically enters a low current state, dropping the battery drain current to less than 1 $\mu$ A. Other features include under voltage lockout, automatic recharge and two status pins to indicate charge termination.

## FEATURES

- Programmable Charge Current range from 3mA to 500mA
- VCC input reverse connect protection
- Lithium-ion batteries Reverse battery protection
- VCC input overvoltage protection 16V
- Maximize Charge Rate Without Risk of Overheating
- For Single Cell titan acid Lithium-Ion Batteries
- Trickle, constant-current and constant-voltage control
- Charges Single Cell Li-Ion Batteries Directly from USB Port
- Preset Charge Voltage with 1% Accuracy
- Automatic Recharge
- Two Charge Status Output Pins
- C/10 Charge Termination
- 140 $\mu$ A Supply Current in Shutdown
- Available in 6-Lead SOT-23/DFN2\*2 Package

## APPLICATIONS

- Miniature lithium battery
- Cellular phone、PAD、MP3 player

## ABSOLUTE MAXIMUM

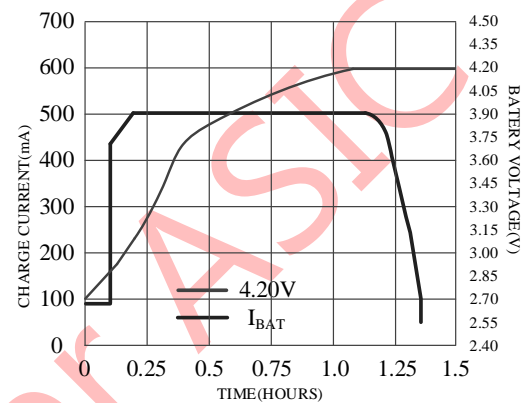
## RATINGS

- Input Supply Voltage(VCC): -6.5V~25V
- PROG: -0.3V~9V
- BAT: -4.2V~9V
- CHRГ: -6.5V~25V
- STDBY: -6.5V~25V
- BAT Short-Circuit Duration:  
Continuous
- BAT Pin Current: 500mA
- PROG Pin Current: 2mA
- Maximum Junction Temperature:  
150°C
- Operating Ambient Temperature  
Range: -40°C~85°C

- Storage Temperature Range: -65°C~125°C
- Lead Temperature(Soldering, 10sec):  
260°C

## Complete Charge Cycle

### (500mAh Battery)



## TYPICAL APPLICATION

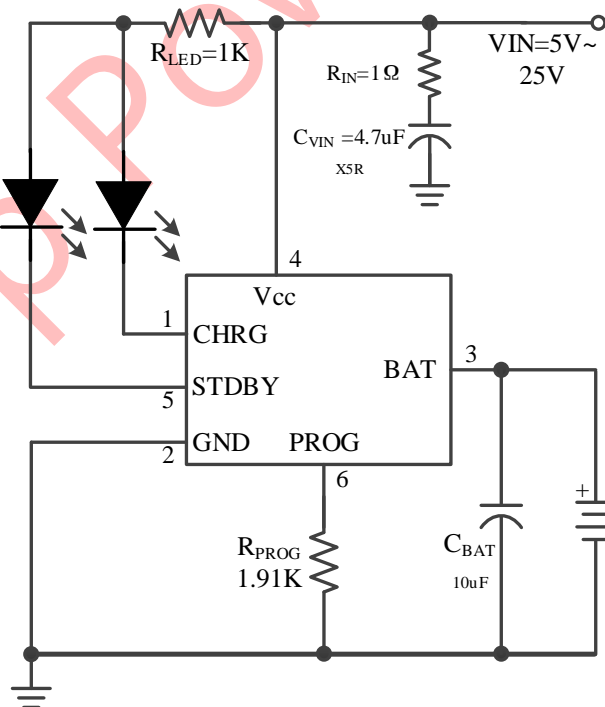
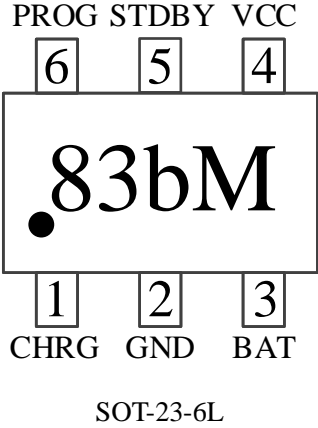
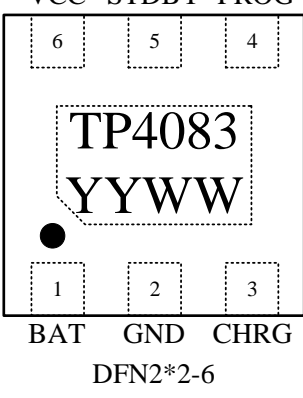


Figure 1 500mA Single Cell Li-Ion Charger

## PACKAGE DESCRIPTION

 <p>PROG STDBY VCC 6 5 4 83bM 1 2 3 CHRG GND BAT SOT-23-6L</p>	<p><b>ORDER PART NUMBER</b></p> <p><b>TP4083-42-SOT236</b></p> <p><b>PART MARKING</b></p> <p>83bM(b is immutable, representing a preset voltage of 4.2V. M variable, representing the month of production.)</p>
 <p>VCC STDBY PROG 6 5 4 TP4083 YYWW 1 2 3 BAT GND CHRG DFN2*2-6</p>	<p><b>ORDER PART NUMBER</b></p> <p><b>TP4083-42-DFN226</b></p> <p><b>PART MARKING</b></p> <p>First line: TP4083 Second line: YYWW (YY is the last two digits of the year, and WW is the corresponding number of weeks.)</p>

### Pin Description

**CHRG (Pin1): Open Drain Charge Status Output** When the battery is being charged, the CHRG pin is pulled low by the internal switch to indicate that charging is in progress; otherwise, the CHRG pin is in a high-impedance state.

**GND (Pin2): Ground Terminal**

**BAT (Pin3): Battery Connection Pin**  
This pin provides the charging current to the battery and adjusts the final float voltage to 4.2V. An accurate internal resistor divider for this pin sets the float voltage, which in the shutdown mode, the internal resistor divider is disconnected.

**Vcc (Pin4): Positive Input Supply Voltage**

This pin supplies power to the internal circuit. The maximum input voltage is 25V. When the input voltage exceeds 16V, the chip enters the shutdown protection mode. Connect a 4.7 $\mu$ F or larger X5R ceramic decoupling capacitor here. It is recommended to place the capacitor very close to the pin. Additional capacitors may need to be connected to stabilize the input voltage. When Vcc drops to within 80mV of the BAT pin voltage, TP4083 enters low power sleep mode, dropping BAT pin's current to less than 1 $\mu$ A.

**STDBY (Pin5): Open Drain Charge Status.**

When the battery Charge Termination, the STDBY pin is pulled low by the internal switch to indicate that charging is in progress; otherwise, the STDBY

pin is in a high-impedance state.

**PROG (Pin6): Charge current setting, charge current monitoring and shutdown pin**

A precision of 1% of the resistance RPROG between the pin and ground to set the charge current. When in constant charge current mode, the voltage of the pin is maintained at 1V.

The PROG pin can also be used to turn off the charger. Setting the resistor to

ground, a 0.2μA current internally pulls the PROG pin high. When the pin voltage reaches the shutdown threshold voltage 2.7V, the charger enters shutdown mode, charging is stopped and the input supply current to 140μA. Re-connecting RPROG to ground will cause the charger to return to normal operation

**DIAGRAM**

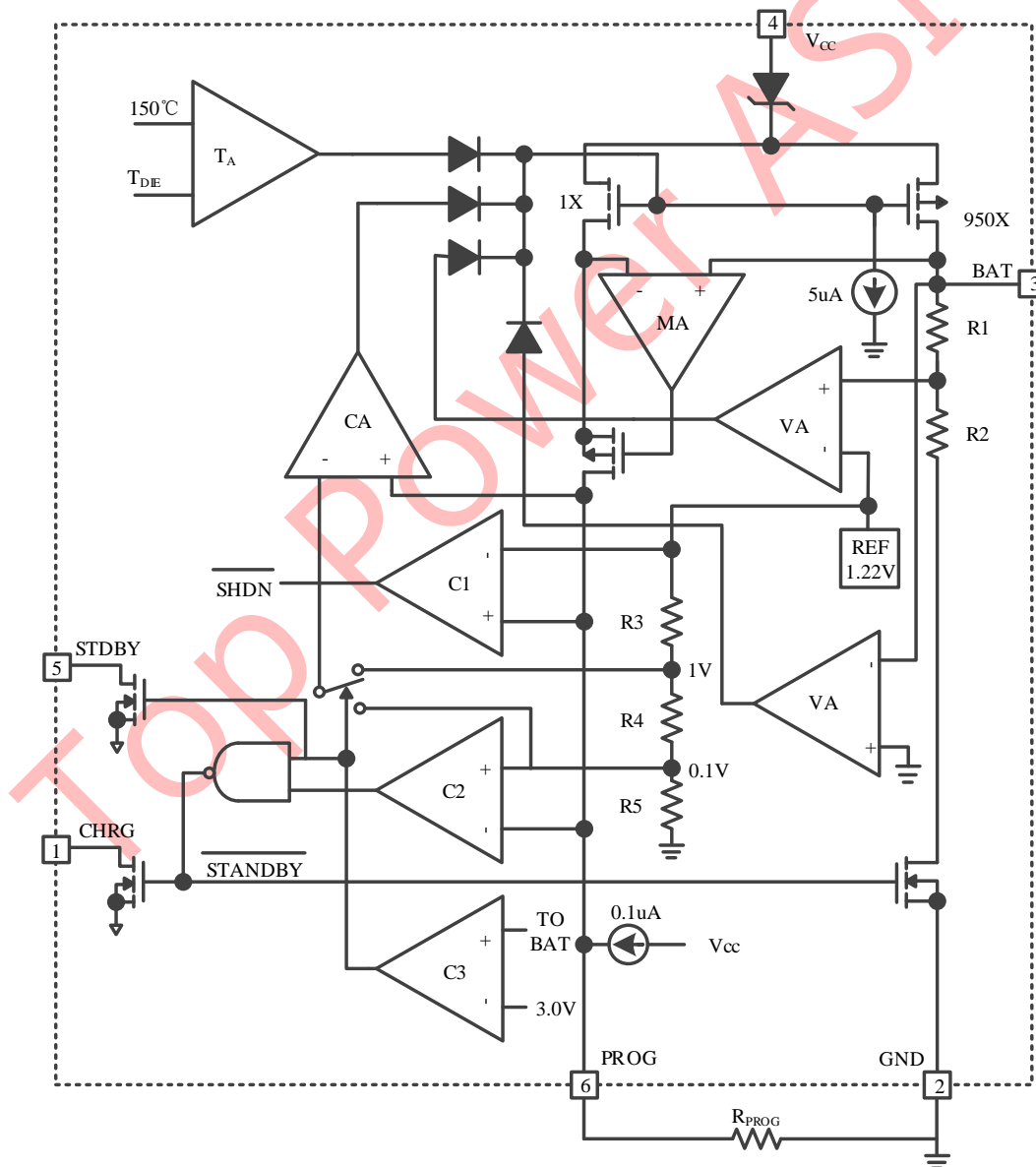


Figure 2 functional block diagram

## ELECTRICAL CHARACTERISTICS

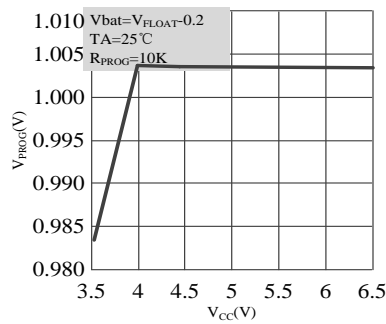
The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A=25^{\circ}\text{C}$ ,  $V_{CC}=5\text{V}$ , unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$V_{CC}$	Input Supply Voltage		● 4.2	5	25	V
$V_{OVP}$	Overshoot protection point		● 15	16	17	V
$I_{CC}$	Input Supply Current	Charge Mode, $R_{PROG} = 10\text{K}$ Standby Mode (Charge Terminated), Shutdown Mode ( $R_{PROG}$ Not Connected, $V_{CC} < V_{BAT}$ , or $V_{CC} < V_{UV}$ )	● 100	140	180	$\mu\text{A}$
$V_{FLOAT}$	Regulated Output (Float) Voltage	$0^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$ , $R_{PROG}=10\text{K}$ , $I_{BAT}=25\text{mA}$	4.158	4.2	4.242	V
$I_{BAT}$ (Take the cut-off voltage 4.2V for example)	BAT Pin Current (Test condition: $V_{BAT}=4.0\text{V}$ )	$R_{PROG}=300\text{K}$ , Current Mode $R_{PROG}=10\text{K}$ , Current Mode $R_{PROG}=1.91\text{K}$ , Current Mode Standby Mode, $V_{BAT} = 4.3\text{V}$ Shutdown Mode( $R_{PROG}$ Not Connected) Sleep Mode, $V_{CC} = 0\text{V}$	● 2.7 ● 99 ● 450 ●	3 110 500 -2.5	3.3 121 550 -6	$\text{mA}$ $\text{mA}$ $\text{mA}$ $\mu\text{A}$
$I_{TRIKL}$	Trickle Charge Current	$V_{BAT} < V_{TRIKL} - 0.4\text{V}$ , $R_{PROG}=10\text{K}$	● 16	18	20	$\text{mA}$
$V_{TRIKL}$	Trickle Charge Threshold Voltage	$R_{PROG}=10\text{K}$ , $V_{BAT}$ Rising	3.0	3.1	3.2	V
$V_{TRHYS}$	Trickle Charge Hysteresis Voltage	$R_{PROG}=10\text{K}$	400	460	500	$\text{mV}$
$V_{UV}$	$V_{CC}$ UVLO Voltage	$V_{CC}$ from low to high	● 3.6	3.8	4.0	V
$V_{UVHYS}$	$V_{CC}$ UVLO Hysteresis		● 48	52	56	$\text{mV}$
$V_{ASD}$	$V_{CC}-V_{BAT}$ lockout threshold voltage	$V_{CC}$ from low to high $V_{CC}$ from high to low	160 70	180 80	200 90	$\text{mV}$ $\text{mV}$
$I_{TERM}$	C/10 termination current threshold	$R_{PROG}=10\text{K}$ $R_{PROG}=1.91\text{K}$	● 16 ● 90	18 100	20 110	$\text{mA}$ $\text{mA}$
$V_{PROG}$	PROG pin voltage	$R_{PROG}=10\text{K}$ , current mode	● 0.92	0.95	0.98	V
$I_{\overline{CHRG}}$	CHRG pin leakage current	$V_{CHRG}=5\text{V}$ Standby Mode		0	1	$\mu\text{A}$
$V_{\overline{CHRG}}$	CHRG Pin output low voltage	$I_{\overline{CHRG}} = 3\text{mA}$		2	2.2	V
$I_{\overline{STDBY}}$	STDBY pin leakage current	$V_{STDBY}=5\text{V}$ Standby Mode		0	1	$\mu\text{A}$
$V_{\overline{STDBY}}$	STDBY Pin output low voltage	$I_{\overline{STDBY}} = 3\text{mA}$		2	2.2	V
$\Delta V_{RECHRG}$	Recharge battery threshold voltage	$V_{FLOAT} - V_{RECHRG}$	60	80	100	$\text{mV}$
$T_{LIM}$	Junction Temperature in Constant Temperature Mode			150		$^{\circ}\text{C}$

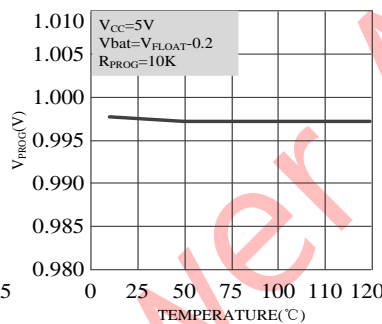
$R_{ON}$	The resistance of power FET ON (between VCC and BAT)				1.5		$\Omega$
t <sub>SS</sub>	Soft start time	$I_{BAT}=0$ to $I_{BAT}=500\text{mA}$			50		$\mu\text{s}$
t <sub>RECHARGE</sub>	Recharge comparator filter time	$V_{BAT}$ from high to low		0.5	1.0	1.5	ms
t <sub>TERM</sub>	Recharge comparator filter time	$I_{BAT}$ drops below $I_{CHG}/10$		0.5	1.0	1.5	ms
$I_{PROG}$	PROG pin pull-up current				0.2		$\mu\text{A}$
$I_{VIN}$	VIN reverse leakage current	VIN reverse, $V_{BAT} = V_{FLOAT}$		0	1.5	2	mA
$I_{BAT}$	BAT reverse leakage current	BAT reverse, $V_{IN} = 5\text{V}$		2	3	10	mA

## TYPICAL PERFORMANCE CHARACTERISTICS

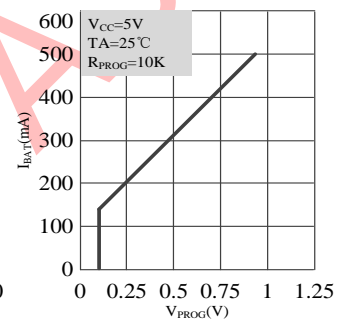
**PROG Pin Voltage vs Supply Voltage**  
(Constant Current Mode)



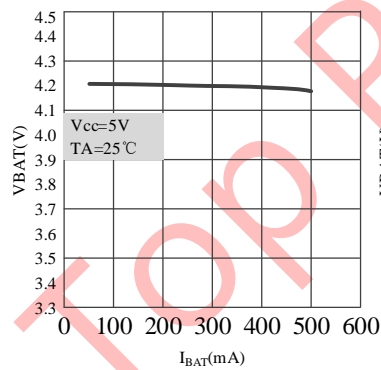
**PROG Pin Voltage vs Temperature**



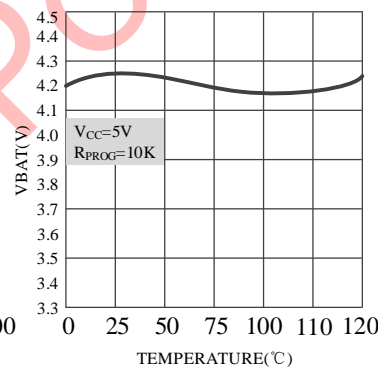
**Charge Current vs PROG Pin Voltage**



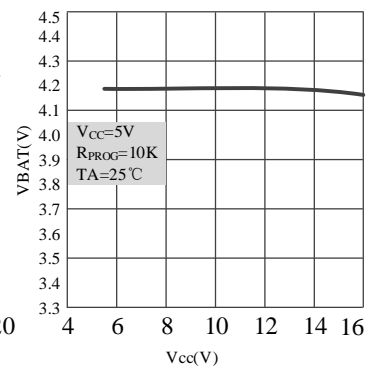
**Regulated Output (Float) Voltage vs Charge Current**



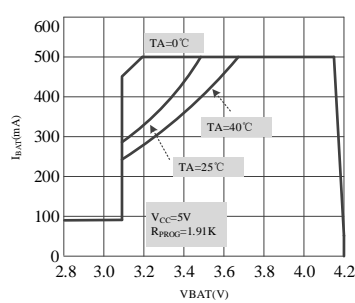
**Regulated Output (Float) Voltage vs Chip Temperature**



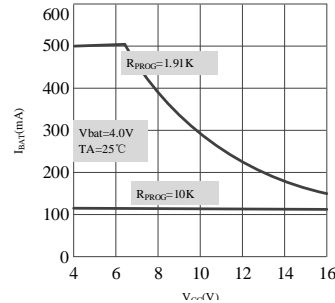
**Regulated Output (Float) Voltage vs Supply Voltage**



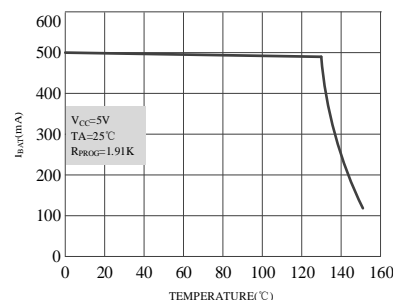
**Charge Current vs Battery Voltage**



**Charge Current vs Supply Voltage**



**Charge Current vs Chip Temperature**



## OPERATION

TP4083 is a single lithium ion battery charger using constant current/constant voltage algorithm. It is capable of delivering 3mA-500mA charging current (with the help of a thermally designed PCB layout) and an internal P-channel power MOSFET and thermal regulation circuit. The charger circuit requires only three external components. In addition, the TP4083 can also obtain a working power supply from a USB power supply, and has input power overvoltage protection, which ensures that the chip is not damaged in complex input environments.

### Normal charging cycle

A charging cycle begins when the Vcc pin voltage rises above the UVLO threshold level and a 1% precision setting resistor is connected between the PROG pin and ground or when a battery is connected to the charger output. If the BAT pin level is lower than the trickle charging threshold voltage 3.1V, then the charger enters the trickle charging mode. In this mode, the TP4083 provides about 20% of the set charging current in order to raise the current voltage to a safe level for full current charging.

When the BAT pin voltage rises above the trickle charging threshold voltage, the charger enters the constant current mode, which provides a constant charging current to the battery. When the BAT pin voltage reaches the final floating charging voltage 4.2V, TP4083 enters the constant voltage mode and the charging current begins to decrease. When the charging current drops to 1/10 of the set value, the charging cycle ends.

### Charging current setting

The charging current is set by a resistor connected between the PROG pin and the ground. The setting resistor and charging

current are calculated by the following formula, and the resistance value of the resistor is determined according to the required charging current:

$$\text{Formula one : } R_{PROG} = \frac{1100}{I_{BAT}} \quad (I_{BAT} \leq 0.1A)$$

$$\text{Formula two: } R_{PROG} = \frac{950}{I_{BAT}} \quad (I_{BAT} > 0.1A)$$

In applications larger than 0.4A, the chip heat is relatively large, and the temperature protection will reduce the charging current, and the test current in different environments is not completely consistent with the theoretical value calculated by the formula. In customer applications, an RPROG of an appropriate size can be selected as required ( for reference only ) .

RPROG (K)	I <sub>BAT</sub> (mA)
300	3
200	5.5
10	110
2.37	400
1.91	500

### Charge termination

The charging cycle is terminated when the charging current drops to 1/10 of the set value after reaching the final floating charging voltage. This condition is detected by using an internal filter comparator to monitor the PROG pins. Charging is terminated when the PROG pin voltage drops below 100mV for more than tTERM(generally 1ms). The charging current is locked off, and the TP4083 enters the standby mode. At this time, the input power current drops to 140μA. (Note: C/10 terminates in trickle charging and heat limiting modes).

When charging, the transient load on the BAT pin will cause the PROG pin voltage to drop below 100mV temporarily between 1/10 of the



DC charging current to the set value. The 1ms filter time (tTERM) on the termination comparator ensures that transient loads of this nature do not cause premature termination of the charging cycle. Once the average charging current drops below 1/10 of the set value, the TP4083 terminates the charging cycle and stops providing any current through the BAT pin. In this state, all loads on the BAT pins must be powered by batteries.

In standby mode, TP4083 continuously monitors the BAT pin voltage. If the pin voltage drops below the recharging voltage threshold ( $V_{RECHRG}$ ), another charging cycle starts and supplies current to the battery again. When manual restart of the charging cycle is performed in standby mode, either the charger must be cancelled and then the input voltage applied, or the charger must be turned off and restarted using the PROG pin. Figure 4 shows the state diagram of a typical charging cycle.

## Battery reverse connection

### protection function

TP4083 has the function of lithium battery reverse connection protection. When the positive and negative batteries are reversely connected to the TP4083 current output BAT pin, TP4083 will shut down and display a fault status without charging current. The two charging indicator pins are in a high resistance state, and the LED is bright. At this time, the leakage current of the reverse battery is less than 5mA. When the reverse battery is connected correctly, TP4083 will start charging cycle automatically.

After the reverse connection of TP4083, when the battery is removed, the TP4083 indicator light will not immediately light up normally because the output terminal BAT pin capacitance potential of TP4083 is still negative. Only when the battery is correctly connected can charging be automatically

activated. Alternatively, if the negative potential of the BAT terminal capacitor is discharged for a long time, and the BAT terminal potential is greater than zero volts, TP4083 will display a normal no battery indicator light status.

In the case of reverse connection, the power supply voltage should be around 5V standard voltage, should not exceed 6.5V. When the power supply voltage is too high, the voltage difference of the chip will exceed the limit voltage.

## VIN input reverse connection protection function

TP4083 also has a power reverse protection function. When the positive and negative terminals of the VIN are reversed at the TP4083 VCC pin, TP4083 will shut down and display a fault status with no charging current. The two charging indicator pins are in a high resistance state, and the LED light is off. At this time, the reverse connected power supply leakage current is less than 10  $\mu$ A. Connect the reversed power supply correctly, and TP4083 will automatically start the charging cycle. TP4083 is equipped with OVP function. When the input voltage exceeds 16V, TP4083 will shut down and display a fault status with no charging current. The two charging indicator pins are in a high resistance state, and the LED light is off. At this time, the static electrical current of the power supply is about 140  $\mu$ A. When the voltage drops to 15V, the chip will start charging again.

## Charging status indicator

### (CHRG, STDBY)

The TP4083 has two drain open state indicating outputs, CHRG and STDBY. When the charger is in charge state, CHRG is pulled to low level, and in other states, CHRG is in

high resistance state. When the battery is not connected to the charger, CHRG outputs a pulse signal indicating that the battery is not installed. When the external capacitor connected to the battery end is  $1\mu\text{F}$ , the CHRG flashing period is about 0.1-0.8 seconds; when the external capacitor of the BAT pin connected to the battery end is  $10\mu\text{F}$ , the CHRG flashing period is about 0.5-3 seconds. If not using a status indicator, the pins should be connected to GND.

Charger's Status	Red LED $\overline{\text{CHRG}}$	Green LED $\overline{\text{STDBY}}$
Charging	ON	OFF
Charging Completes	OFF	ON
Power supply undervoltage, reverse connection, overvoltage	OFF	OFF
Reverse battery connection	Micro-light	OFF
BAT pin is connected to $10\mu\text{F}$ capacitor, and not connect to battery	Flickering	ON

Note: When connecting a 100K resistor to the power supply at the BAT end, the power supply will charge the battery through the resistor, with a size of approximately  $8\mu\text{A}$ . This small current, even if not removed in a timely manner after the battery is fully charged, will not cause harm to the battery such as overcharging.

### Thermal limiting

If the chip temperature attempts to rise above the preset value of about  $150\text{ }^\circ\text{C}$ , an internal thermal feedback loop will reduce the set charging current. This function can prevent TP4083 from overheating and allow users to increase the upper limit of the given circuit board's power processing capacity without the risk of damaging TP4083. On the premise of

ensuring that the charger will automatically reduce the current under worst-case conditions, the charging current can be set based on typical (rather than worst-case) ambient temperature. The power considerations will be further discussed in the "thermal considerations" section.

### Undervoltage lockout

An internal undervoltage blocking circuit monitors the input voltage and keeps the charger in shutdown mode before the VCC rises above the undervoltage blocking threshold. The UVLO circuit will keep the charger in shutdown mode. If the UVLO comparator jumps, the charger will not exit shutdown mode until the VCC rises to 50mV higher than the battery voltage.

### Manual stop

The TP4083 can be put into shutdown mode at any time during the charging cycle by removing the RPROG (thus making the PROG pin float). This reduces the battery leakage current to less than  $1\mu\text{A}$  and the power supply current to less than  $140\mu\text{A}$ . Reconnecting the setting resistor initiates a new charging cycle. Figure 3. PROG pins float with NMOS tube off.

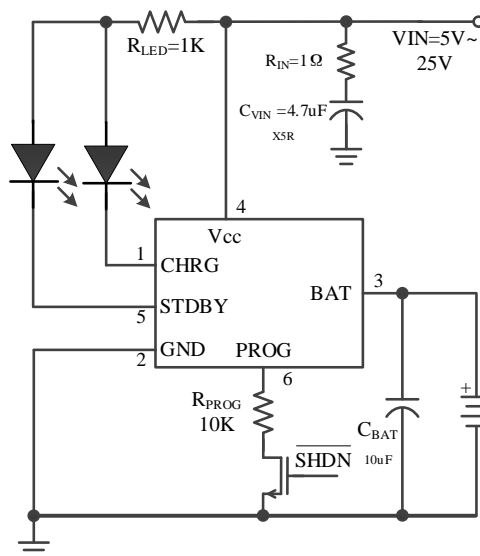


Figure 3

## Automatic restart

Once the charging cycle is terminated, the TP4083 immediately employs a comparator with a 1ms filter time ( $t_{RECHARGE}$ ) to continuously monitor the voltage on the BAT pin. The charging cycle restarts when the battery voltage drops below the recharging voltage point, which roughly corresponds to 80 to 90 percent of the battery capacity. This ensures that the battery is maintained at (or near) a full charge and obviates the need to start a periodic charging cycle. During the recharging cycle, the CHRG pin output re-enters a strong pull-down state.

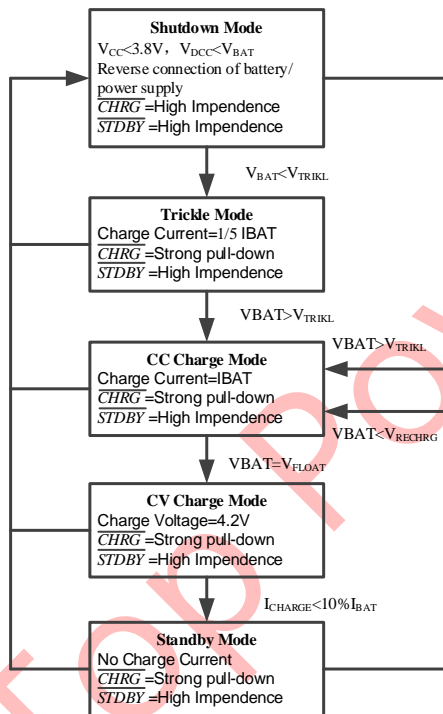


Figure 4 State diagram of a typical charging cycle

## Stability and reliability

### considerations

When the battery is not connected, in order to prevent the connection of VCC or BAT to produce high-energy burrs, it is strongly required to add a 10 $\mu$ F capacitor at the VCC

and BAT ends. And according to the input environment to select different voltage resistance, material capacitors. A 50V X5R capacitor is recommended.

## Thermal consideration

Due to the small dimensions of SOT23-6 and DFN2\*2-6 packages, poor heat dissipation in high-current applications (above 400mA) may cause the charging current to be reduced by temperature protection. Design the heat dissipation resistance according to the actual power supply voltage. Generally, the heat dissipation resistance is 0.1 to 0.5 ohms. It is also important to use a thermally designed PCB layout to maximize the available charging current. SOT23 package used to dissipate the heat generated by the IC heat dissipation path from the chip to the lead frame, and through the lead (especially the ground lead) to the PCB copper surface, DFN2\*2 package can not only through the frame can also be directly connected to the PCB through the heat sink. The copper side of PCB is a heat sink. The copper foil area connected with the pins and heat sinks should be as wide as possible, and a larger copper area should be extended outwards in order to disperse heat to the surrounding environment. When designing the PCB layout, other heat sources on the board that are not related to the charger must also be considered, because they will have an impact on the overall temperature rise and maximum charging current.

## VCC bypass resistor capacitor

The input bypass can use multiple types of capacitors in series with a single resistor. Caution must be exercised when using multilayer ceramic capacitors. Because some types of ceramic capacitors have the characteristics of self-resonance and high Q value, it is possible to generate high voltage transient signals under certain starting

conditions (such as connecting the charger input to a working power supply), it is recommended to use high-quality ceramic capacitors or tantalum capacitors. Different qualities also determine the maximum voltage of the chip input.

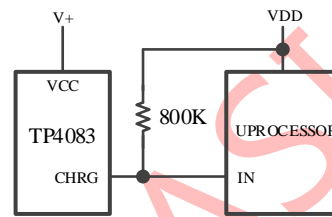
### Charging current soft start

The TP4083 includes a soft start circuit for minimizing the inrush current at the beginning of the charge cycle. When a charge cycle is started, the charge current will rise from 0 to the full scale value in about 50 $\mu$ s. This minimizes the transient current load on the power supply during startup.

### CHRG state output pin

When a discharged battery is connected to a charger, the constant current part of the charging cycle begins, and the CHRG pin level is pulled to ground. The CHRG pin can absorb up to 10mA of current to drive an LED indicating that a charging cycle is in progress. As the battery approaches full charge, the charger enters the constant voltage part of the

charging cycle, and the charging current begins to decrease. When the charging current drops below 1/10 of the set current, the charging cycle ends and is replaced by a strong pull-down high resistance state, indicating that the charging cycle has ended. If the input voltage is removed, the CHRG pin will also become high impedance. Using a pull-up resistor, a microprocessor can detect these two states from this pin, as shown in Figure 5.

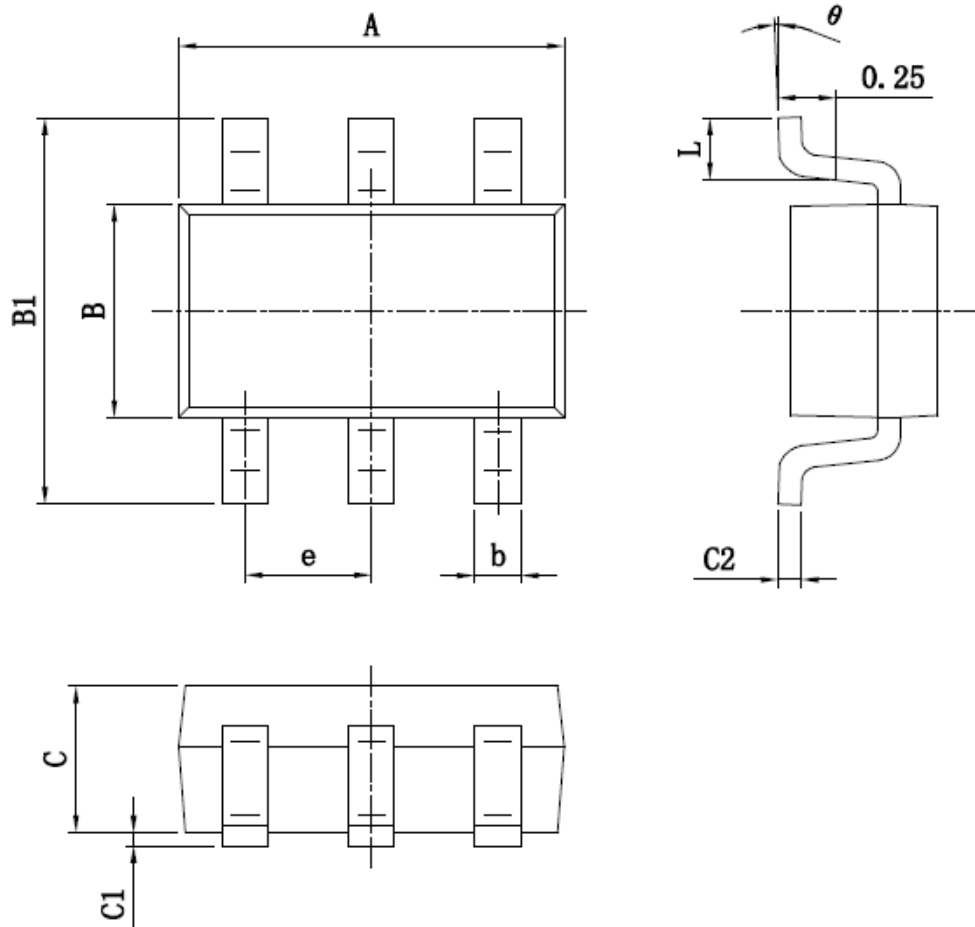


In order to detect when TP4083 is in charging mode, NMOS pulls the pin to a low level using a 100K pull-up resistor. Once the charging cycle is terminated, the NMOS is turned off, and the CHRG pin is a high impedance IN pin, which is then pulled to a high level by a 100K pull-up resistor.

## Packaging description

### SOT23-6

尺寸 标注	最小(mm)	最大(mm)	尺寸 标注	最小(mm)	最大(mm)
A	2.82	3.02	C	1.05	1.15
e	0.95 (BSC)		C1	0.03	0.15
b	0.28	0.45	C2	0.12	0.23
B	1.50	1.70	L	0.35	0.55
B1	2.75	3.05	$\theta$	0°	8°



DFN2\*2-6

标注	尺寸	最小(mm)	标准(mm)	最大(mm)	标注	尺寸	最小(mm)	标准(mm)	最大(mm)
A		0.70	0.75	0.80	E2		0.75	0.80	0.85
A1		0.00	0.02	0.05	e		0.650B3C		
b		0.30	0.35	0.40	Nd		1.300B3C		
c		0.18	0.20	0.25	K		0.20	-	-
D		1.95	2.00	2.05	L		0.28	0.33	0.38
D2		1.25	1.30	1.35	h		0.15	0.20	0.25
E		1.95	2.00	2.05					

