南京拓品微电子有限公司

NanJing Top Power ASIC Corp.

数据手册

DATASHEET

TP4069

(10mA-800mA Linear Li-Ion Battery Charger)

DESCRIPTION

TP4069 is a complete single cell lithium battery charger with a single chip positive and negative pole reverse protection, compatible with charging currents ranging from 10mA to 800mA., and it includes trickle, constant-current and constant-voltage. Its SOT23-6、DFN2*2-6 package and low external component count make the TP4069 ideally suited for portable applications. TP4069 is suitable for working with USB power supplies and adapter power supplies. Internally, thermal feedback is used to automatically adjust the charging current, in order to limit the chip temperature during high-power operation or high ambient temperature conditions. The charging current can be set externally through a resistor. When the battery reaches the preset voltage and the charging current drops to 1/10 of the set value, TP4069 will automatically terminate charging.

When the input voltage (AC adapter or USB power supply) is removed, TP4069 automatically enters a low current state, and the battery leakage current is at 1 μ Below A. Other features of TP4069 include power adaptive, undervoltage lockout, automatic recharging, battery temperature protection function, and a status pin for indicating charging.

TP4069 adopts SOT23-6 package with a charging current range of 10mA-600mA, and DFN2*2-6 package with a charging current range of 10mA-800mA.

FEATURES

- Programmable Charge Current range from 10mA to 800mA
- Lithium-ion batteries Reverse battery protection
- Equipped with battery temperature detection function
- Trickle, constant-current and constant-voltage control
- Charges Single Cell Li-Ion Batteries Directly from USB Port
- Preset Charge Voltage with 1% Accuracy
- Highest input can be up to 9V
- Automatic Recharge
- One Charge Status Output Pins
- C/10 Charge Termination
- 95uA Supply Current in Shutdown

APPLICATIONS

- Micro lithium battery, charging dock, mobile power supply
- Intelligent wearable and handheld mobile devices
- Bluetooth applications

TYPICAL APPLICATION

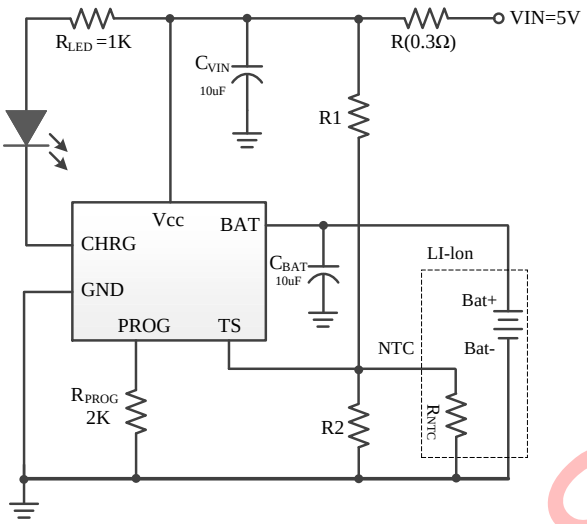
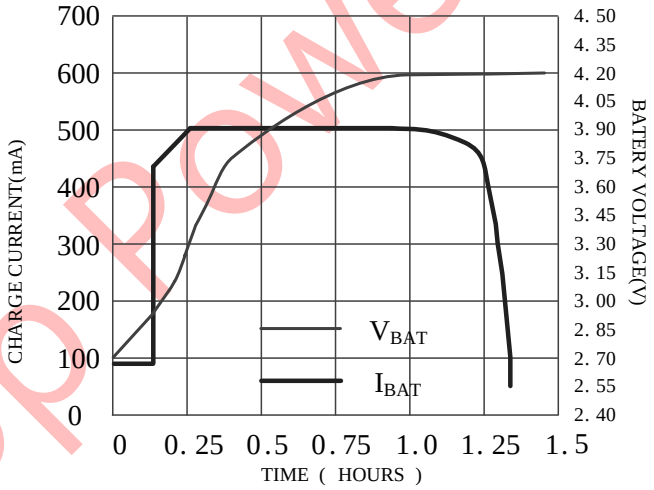


Figure 1　500mA Single Cell Li-Ion Charger

Note: Proposed R1 dissipation resistor, it can get a larger charge current, and also improve the reliability of the machine. Resistance is selected according to the actual situation　(0 ~ 0.6Ω).

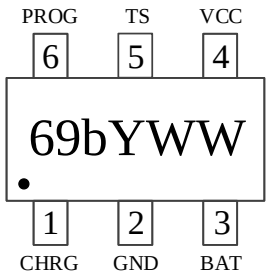
Complete Charge Cycle (500mAh Battery)

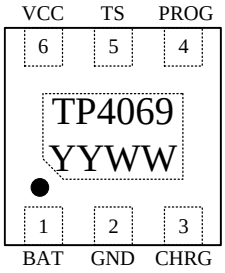


ABSOLUTE MAXIMUM RATINGS

- VCC：0V～9V
- PROG：00V～VCC+0.3V
- BAT：-4.2V～7V
- CHRG：-0.3V～9V
- TS：0V～9V
- BAT Pin Current：900mA
- PROG Pin Current：2mA
- Maximum Junction Temperature：145℃
- Operating Ambient Temperature Range：-40℃～85℃
- Storage Temperature Range：-65℃～125℃
- Lead Temperature(Soldering, 10sec)：260℃
- ESD-HBM：4KV

PACKAGE DESCRIPTION





ORDER PART NUMBER
TP4069-4.2V-SOT236 **TP4069-4.2V-DFN226**
PART MARKING
69bYWW→4.2V YWW represents production year and week

Pin Description

Pin	Package		Function Description
	SOT23-6	DFN2*2-6	
CHRG	1	3	Charging status indicator terminal for open drain output
GND	2	2	Power supply ground
BAT	3	1	Chip output connected to battery terminal
VCC	4	6	Chip power input terminal
TS	5	5	Battery temperature detection input terminal
PROG	6	4	Charging current setting, charging current monitoring, and shutdown pin terminal

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at TA=25℃， VCC=5V，unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
VCC	Input Supply Voltage		●	4.35	5	9.0	V
ICC	Input Supply Current	Charge Mode, RPROG = 10k StandbyMode(Charge Terminated) Shutdown Mode (RPROG Not Connected,VCC < VBAT, or VCC < VUV)	● ● ●		95 95 95	120 120 120	μA μA μA
VFLOAL	Regulated Output (Float) Voltage	0 ℃ ≤ TA ≤ 85 ℃ ，IBAT=20mA,Rprog=10K		4.158	4.2	4.242	V
IBAT (Take the cut-off voltage 4.2V for example)	BAT Pin Current (Except that VBAT=4.0V)	RPROG = 100k, Current Mode RPROG = 10k, Current Mode RPROG = 2k, Current Mode Standby Mode, VBAT = 4.3V Shutdown Mode (RPROG Not Connected) Sleep Mode, VCC = 0V	● ● ●	8 90 425	11 105 500 -2.3 ±1 0	14 120 575 -6 ±2 -1	mA mA mA μA μA μA
IBAT （DFN226）	BAT Pin Current (Except that VBAT=4.0V)	RPROG = 1.32k, Current Mode RPROG = 1..12k, Current Mode	● ●	630 720	700 800	770 880	mA mA
ITRIKL	Trickle Charge Current	V_{BAT}<V_{TRIKL}-0.4V，R_{PROG}=10K	●	15	20	25	mA
VUV	VCC Undervoltage Lockout Threshold	From VCC Low to High	●	3.6	3.8	4.0	V
ITERM	C/10 Termination Current Threshold	R_{PROG}=10K R_{PROG}=2K	● ●	6 30	8 50	10 70	mA mA
VPROG	PROG Pin Voltage	RPROG=10K，Current Mode	●	0.9	0.95	1	V
VCHRG	CHRG Pin Outputversr Low Voltage	ICHRG =4.8mA			0.15	1	V
IBAT	Battery reverse leakage current	Battery reverse ,VIN = 5V		5	9	12	mA

OPERATION

TP4069 is a single cell lithium-ion battery charger that uses a constant current/constant voltage algorithm. It can provide a charging current of 10mA-800mA (with the help of a well-designed PCB layout) and an internal P-channel power MOSFET and thermal regulation circuit. No need to isolate diodes or external current detection resistors; Therefore, the basic charger circuit only requires two external components. Not only that, TP4069 can also obtain working power from a USB power supply.

Normal charging cycle

When the voltage of the Vcc pin rises above the UVLO threshold level and a set resistor with an accuracy of 1% is connected between the PROG pin and ground, or when a battery is connected to the output of the charger, a charging cycle begins. If the BAT pin level is below the trickle charging threshold voltage of 2.9V, the charger enters trickle charging mode. In this mode, TP4069 provides approximately 20% of the set charging current to raise the current and voltage to a safe level, thereby achieving full current charging.
When the voltage of the BAT pin rises above the trickle charging threshold voltage, the charger enters constant current mode, providing a constant charging current to the battery. When the voltage of the BAT pin reaches the final float voltage of 4.2V, TP4069 enters a 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 using a resistor connected between the PROG pin and ground. The resistor and charging current are calculated using the following formula, and the resistor resistance value is determined based on the required charging current:

Formula one:

$$R_{PROG} = \frac{1000}{I_{BAT}} \quad (0.6A \geq I_{BAT} > 0.2A)$$

Formula two: $R_{PROG} = \frac{1050}{I_{BAT}}$ $(I_{BAT} \leq 0.2A)$

In applications greater than 0.4A, the chip heat is relatively high, and temperature protection will reduce the charging current. The testing current in different environments and the theoretical value calculated by the formula may not be completely consistent. In customer applications, RPROGs of appropriate size can be selected according to needs.（for reference only）.
If the customer wants to use a charging current greater than 0.6A, please use DFN226 packaging. The resistance value can be directly referred to the table below; In addition, when the battery voltage is below 3.6V, the charging current will decrease due to thermal limitation. When it is above 3.6V, the chip can charge with normal current.

R_{PROG} (K)	I_{BAT} (mA)
100	11
10	105
5	210
2	500
1.66	600
1.32	700
1.12	800

Charge termination

When the charging current drops to 1/10 of the set value after reaching the final float charging voltage, the charging cycle is terminated. This condition is detected by monitoring the PROG pins using an internal filtering comparator.
When the voltage of the PROG pin drops

below 100mV for more than tTERM (usually 20ms), charging is terminated. The charging current is locked off, and TP4069 enters standby mode. At this time, the input power current drops to 95 μA. (Note: C/10 termination fails in trickle charging and thermal limit mode).

During charging, the transient load on the BAT pin will cause the voltage of the PROG pin to briefly drop below 100mV when the DC charging current drops to 1/10 of the set value. The 20ms filtering 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, TP4069 terminates the charging cycle and stops providing any current through the BAT pin. In this state, all loads on the BAT pin must be powered by the battery.

In standby mode, TP4069 continuously monitors the voltage of the BAT pin. If the voltage of the pin drops below the recharge voltage threshold (VRECHRG), another charging cycle begins and current is supplied to the battery again. When manually restarting the charging cycle in standby mode, it is necessary to cancel and then apply input voltage, or the charger must be turned off and restarted using the PROG pin.

Battery reverse connection protection function

TP4069 has a lithium battery reverse connection protection function. When the positive and negative poles of the battery are reverse connected to the current output BAT pin of TP4069, TP4069 will shut down and display a fault status without charging current. The charging indicator pin is in a high resistance state, and the reverse connected battery leakage current is less than 9mA. Connect the reversed battery correctly, and TP4069 will automatically start the charging cycle.

After the reverse connection of TP4069, when the battery is removed, the TP4069 indicator light will not immediately light up normally because the output terminal BAT pin capacitance potential of TP4069 is still negative. Only by correctly connecting the battery 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, TP4069 will display a normal no battery indicator light status.

In reverse connection, the power supply voltage should be around the standard voltage of 5V and should not exceed 5.5V. When the power supply voltage is too high and the battery voltage is reversed, the voltage difference of the chip will exceed the maximum withstand voltage.

Charging status indicator (CHRG)

TP4069 has an open drain status indicator output terminal, CHRG pin, which is the red light pin. When the charger is in the charging state, CHRG is pulled to a low level, and in other states, CHRG is in a high resistance state. When the battery is not connected to the charger, the CHRG outputs a pulse signal indicating that the battery is not installed. When the external capacitance connected to the battery end is 1uF, the CHRG flashing cycle is about 0.1-0.8 seconds, and when the external capacitance of the BAT pin connected to the battery end is 10uF, the CHRG flashing cycle is about 0.5-3 seconds. When the status indicator function is not used, connect the unused status indicator output terminal to ground.

Battery temperature monitoring

In order to prevent damage to the battery caused by high or low temperatures, TP4069 integrates a battery temperature monitoring circuit inside. Battery temperature monitoring is achieved by measuring the voltage of the TS pin, which is achieved by the NTC thermistor inside the battery and a resistor voltage divider network, as shown in the typical application legend.

TP4069 compares the voltage of the TS pins with the two thresholds VLOW and VHIGH inside the chip to confirm if the battery temperature exceeds the normal range. Within TP4069, VLOW is fixed at 45% × VCC and VHIGH are fixed at 80% × VCC. If the voltage VTS of the TS pin is<VLOW or VTS>VHIGH, it indicates that the temperature of the battery is too high or too low, and the charging process will be paused;

If the voltage VTS of the TS pin is between VLOW and VHIGH, the charging cycle will continue.

If the TS pin is connected to the ground wire, the battery temperature monitoring function will be disabled.

Manual stop

At any time during the charging cycle, the RPROG can be removed (thereby floating the PROG pin)Put TP4069 in shutdown mode. This reduces the battery leakage current to 1 μ Below A, and the power supply current drops to 95 μ Below A. Reconnecting the setting resistor can initiate a new charging cycle.

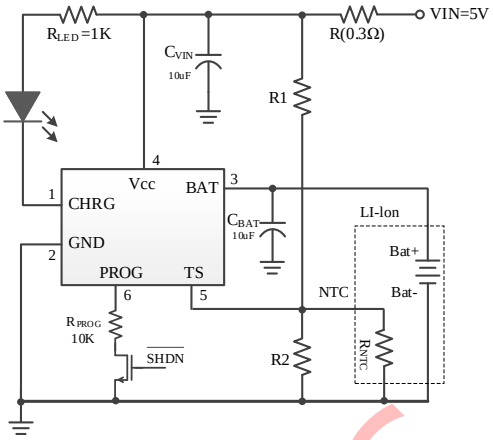


Figure 3 Using NMOS transistor to turn off and float PROG pins

Power adaptive

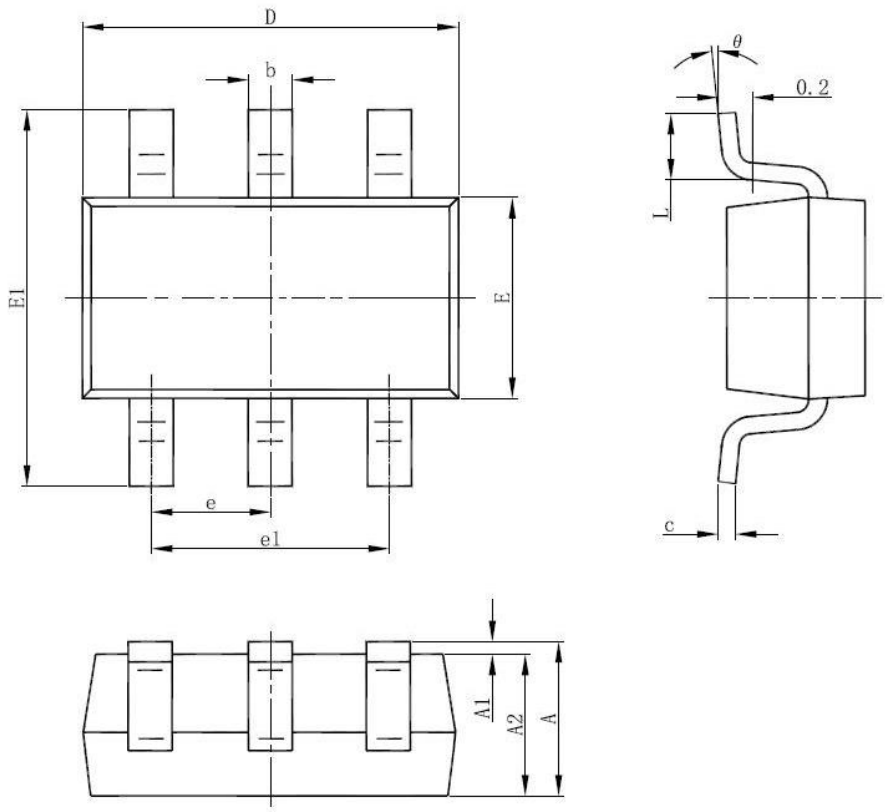
When the VCC loses power to 4.35V, the adaptive circuit starts and automatically reduces the output current until the VCC no longer decreases. This function can use a USB or low-power power adapter or solar cell to power the high current charging system, avoiding power reset or restart.

Automatic restart

Once the charging cycle is terminated, TP4069 immediately uses a comparator with a 20ms filtering time (tRECHARGE) to continuously monitor the voltage on the BAT pin. When the battery voltage drops below the recharge voltage point (roughly corresponding to 80% to 90% of the battery capacity), the charging cycle begins again. This ensures that the battery is maintained at (or close to) a fully charged state and eliminates the need for periodic charging cycles to start. During the recharge cycle, the CHRG pin output enters a strong pull-down state again.

Packaging description

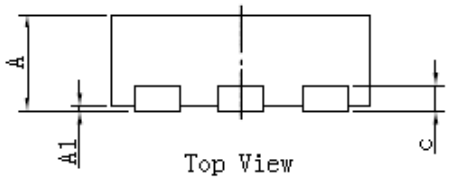
SOT-23-6L PACKAGE OUTLINE DIMENSIONS



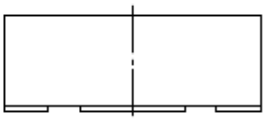
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)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

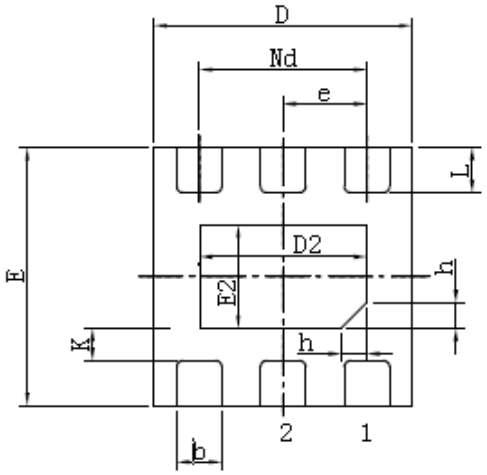
DFN2*2-6

尺寸 / 标注	最小(mm)	标准(mm)	最大(mm)	尺寸 / 标注	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		0.650BSC	
b	0.30	0.35	0.40	Nd		1.300BSC	
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				



Top View


Side View



Bottom View

Other Typical Applications

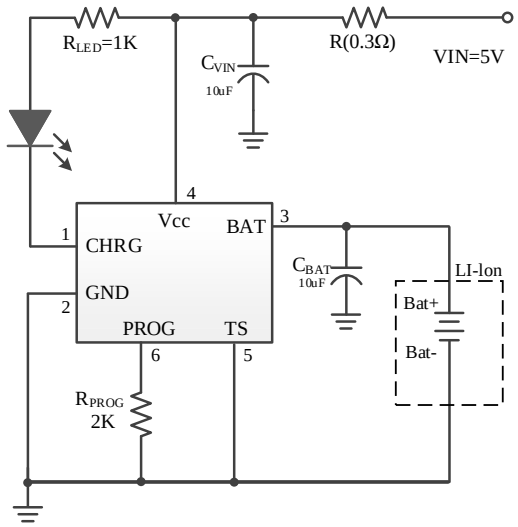


Figure 6: No temperature detection function

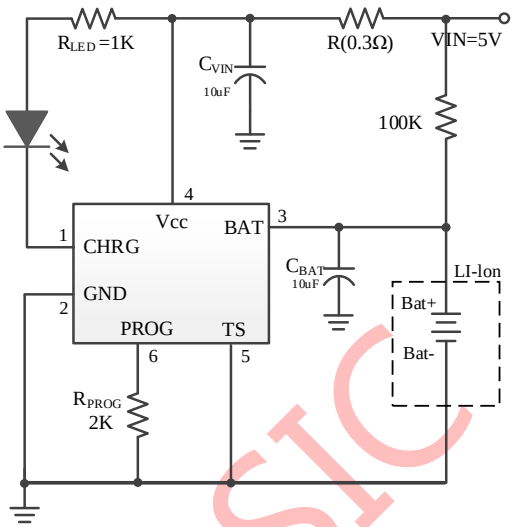


Figure 7 Application diagram of red light off without battery

TP4069 Test Usage Precautions

1. To ensure reliable use in various situations and prevent chip damage caused by spike and burr voltages, it is recommended to connect 10uF ceramic capacitors to the VCC and BAT terminals respectively in TP4069 applications. Capacitors can be packaged in commonly used 0603, 0805, or 1206 packages, and the capacitor ground and TP4069 ground should be connected in a centralized manner. All capacitors should be placed close to the chip pins and not too far away.
2. To test the charging current of TP4069, the BAT end of the chip should be directly connected to the positive electrode of the battery, and an ammeter should not be connected in series. The ammeter can be connected in series to the VCC end of the chip.
3. Using SOT23-6 and DFN2 * 2-6 packaging, poor heat dissipation in high current applications (above 400mA) may cause a decrease in charging current due to temperature protection. Generally, customers can choose not to connect a dissipation resistor. If the current cannot meet the requirements, please design a thermal dissipation resistor based on the actual power supply voltage (the dissipation resistor can not only obtain a stable charging current, but also greatly improve the reliability of the entire system). The optimal input voltage for the VCC end of the chip is 4.8V, which can obtain a larger charging current. Generally, the thermal dissipation resistor is 0.3 to 0.6 Ω, and the power is preferably above 0.15W. A good PCB layout can effectively reduce the impact of temperature on current for customers in high current charging applications.