Nanjing Tuowei Integrated Circuit Co., Ltd.

NanJing Top Power ASIC Corp.

DATASHEET

(TP4054 (TP4054 Linear Li-ion Battery Charger Linear Li-ion Battery Charger)

TP4054 Linear Li-ion Battery Charger

describe

The TP4054 is a complete single-cell Li-ion battery with constant current/constant voltage linear charger. Its **SOT** The small package and low external component count make **the TP4054** ideal for portable applications. TP4054 can fit **USB** power and adapter power work.

Due to the internal **PMOSFET** architecture and anti-backup circuit, no external sense resistor and isolation diode. Thermal feedback regulates charge current to facilitate charging during high power operation or high ambient temperature conditions. chip temperature is limited. The charging voltage is fixed at 4.2V, while the charging current can be set externally through a resistor. When the charging current drops to **1/10** of the set value after reaching the final float voltage , **the TP4054** will automatically terminate the charging cycle.

When the input voltage (AC adapter or **USB** power) is removed, the TP4054 automatically enters a low current state state, reducing the battery leakage current to less than **2uA . The TP4054** can also be placed in shutdown mode to reduce the supply current to **45uA.** Other features of **the TP4054** include a charge current monitor, undervoltage lockout, automatic recharge and a Status pin indicating the end of charging and input voltage access.

Features

·Programmable charge current up to 800mA; ·No MOSFET, sense resistor or isolation diode required; · Complete **SOT23-5** package for single-cell Li-ion batteries

Complete linear charger;

·Constant current/constant voltage operation and features the ability to operate without risk of overheating

Thermal regulation function to maximize charging rate under dangerous conditions;

·Charge a single-cell lithium-ion battery directly from the USB port;

·4.2V preset charging voltage with an accuracy of ±1%; ·Charging current monitor output for battery power detection; ·Automatic recharging;

·Charging status output pin; ·C/10 charge termination;

·Standby mode The power supply current is 45uA; ·2.9V trickle charging device version;

·Soft start limits inrush current; ·Adopts 5-pin SOT-23 package.

absolute maximum ratings

·Input power supply voltage (VCC): -0.3Vÿ10V

·PROGÿ-0.3VÿVCC+0.3V

·BATÿ-0.3Vÿ7V

· $\overline{CHRG}$ ÿ-0.3Vÿ10V

·BAT short circuit duration: continuous

·BAT pin current: 800mA

·PROG pin current: 800uA ·Maximum junction temperature: 145ÿ

·Working environment temperature range: -40ÿÿ85ÿ

·Storage temperature range: -65ÿÿ125ÿ ·Pin temperature (welding time 10 seconds): 260ÿ

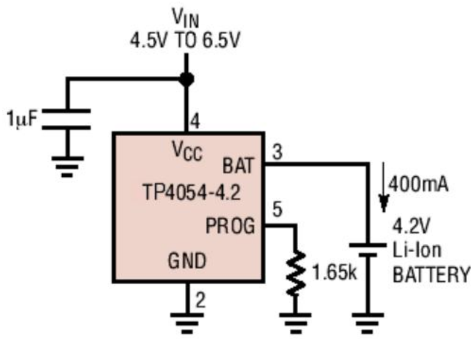
application

·Cellular phones, PDAs, MP3 players; ·Charging cradle;

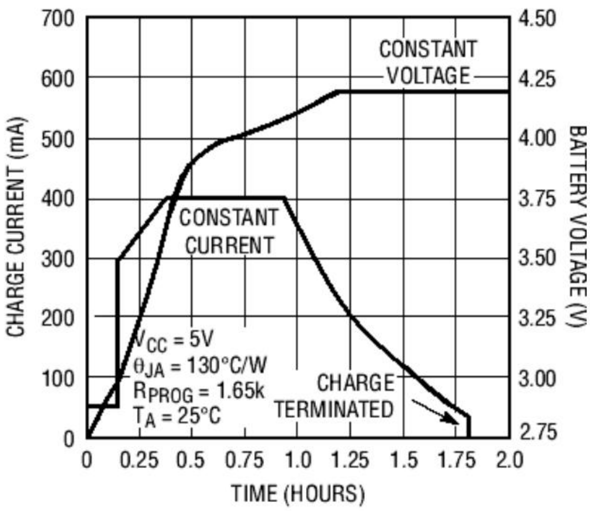
·Bluetooth applications.

Typical application

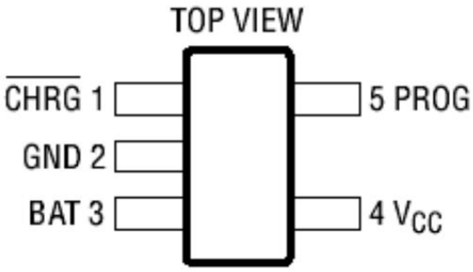
400mA single cell lithium-ion battery charger



完整的充电循环 (650mAh 电池)



Packaging/Ordering Information



5- pin plastic **SOT-23-5** package

Order model
TP4054-42-SOT25-R
Device Marking
54b

Electrical properties

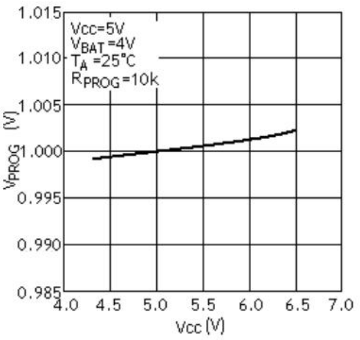
Note • in the table indicates that the indicator is suitable for the entire operating temperature range, otherwise it only refers to TA=25ÿ, VCC=5V, unless otherwise specified ÿ

symbol	parameter	condition		Minimum value	Typical value	Maximum value	Unit
VCC	input supply voltage input		• 4.0		5	9.0	IN
ICC	supply current	**Charging mode, RPROG=10K**	•		150	500	ÿA
		Standby mode (charging terminated)	•		45	100	ÿA
		shutdown mode (RPROG connection,	•		45	100	ÿA
		VCC<VBAT, or VCC<VUV)			45	100	
VFLOAL	Stable output (floating charge) voltage 0ÿÿTAÿ85ÿ,	DIFFERENT=40mA		4ÿ158 4ÿ2	4ÿ242		IN
DIFFERENT	**BAT** pin current	**RPROG=10K, current mode**	•	90	100	110	mA
		RPROG=1.66K, current mode	•	250	400	450	mA
		Standby mode, VBAT=4.2V	•	0	ÿ2.5	ÿ6	ÿA
		shutdown mode (RPROG connection)			±1	±2	ÿA
		Sleep mode, VCC=0V			ÿ1	ÿ2	ÿA
ITRIKL	trickle charging current	**VBAT<VTRIKL,RPROG=10K • 15**			25	35	mA
VTRIKL	trickle charge threshold voltage	**RPROG=10K, VBAT rises**		2.8	2.9	3.0	IN
VTRHYS	trickle charge hysteresis voltage	**RPROG=10K**		60	80	100	mV
VUV	**VCC** undervoltage lockout threshold	From **VCC** low to high	• 3.4		3.6	3.8	IN
VUVHYS	**VCC** undervoltage lockout hysteresis		• 150		200	300	mV
VMSD	Manual shutdown threshold voltage	**PROG** pin level rises	•	3.40	3.50	3.60	IN
		PROG pin level drops	•	1.90	2.00	2.10	IN
VASD	**VCC-VBAT latch threshold voltage**	**VCC** from low to high		60	100	140	mV
		VCC from high to low		5	30	50	mV
ITERM	**C/10** termination current threshold	**RPROG=10K**	•	8	10	12	mA
		RPROG=1.66K	•	30	40	50	mA
VPROG	**PROG** pin voltage	**RPROG=10K, current mode**	• 0.9		1.0	1.1	IN
$I_{\overline{CHRG}}$	$\overline{CHRG}$ Pin weak pull-down current	$V_{\overline{CHRG}}$ =5V		8	20	35	ÿA
$IN_{\overline{CHRG}}$	$\overline{CHRG}$ Pin output low voltage	$I_{\overline{CHRG}}$ =5mA		0.1	0.3	0.5	IN

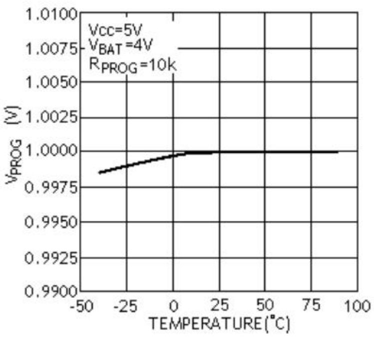
ÿVRECHRG	rechargeable battery threshold voltage **VFLOAT-VRECHRG**			**100**	**150**	**200**	**mV**
	Junction temperature in **TLIM** limited temperature mode				**120**		ÿ
RON	Power FET "on" resistance (Between **VCC** and **BAT**)				**650**		mÿ
tss	soft start time **tRECHARGE**	**IBAT=0** to **IBAT=1000V/RPROG**			**20**		**ÿs**
	recharge comparator filter time **VBAT high to low**			**0.8**	**1.8**	**4**	**ms**
tTERM	terminates comparator filter time	**IBAT falls** below **ICHG/10**		**0.8**	**1.8**	**4**	ms
IPROG PROG	pin pull-up current				**2.0**		**ÿA**

Typical performance characteristics

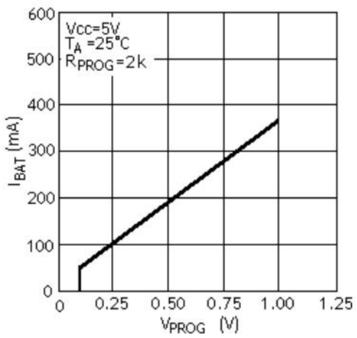
Relationship between **PROG** pin voltage and supply voltage in constant current mode



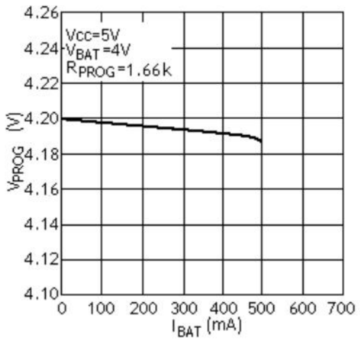
PROG pin voltage vs. temperature curve



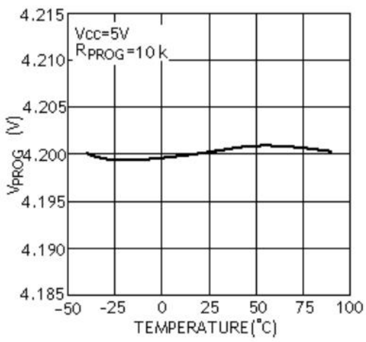
Charging current and **PROG** pin current pressure relationship curve



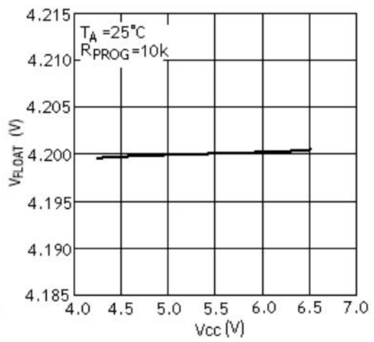
The relationship curve between stable output (float charge) voltage and charging current



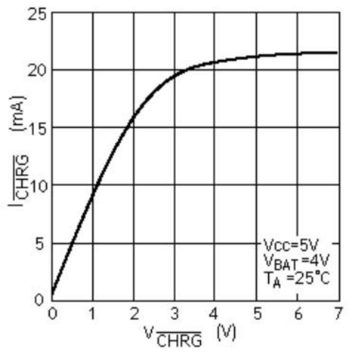
Stable output (float charge) voltage versus temperature curve



Stable output (floating charge) voltage and electricity pressure relationship curve

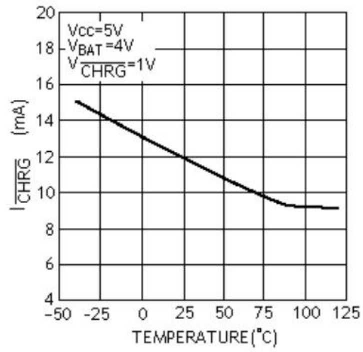


Pin IV curve in strong pull-down state CHRG



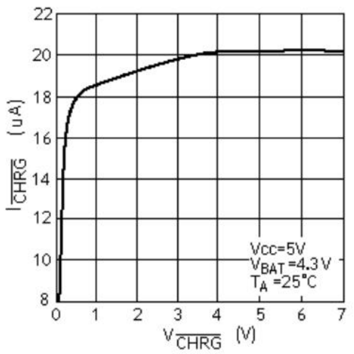
Bootstrap in strong pull-down state CHRG

The relationship between foot current and temperature

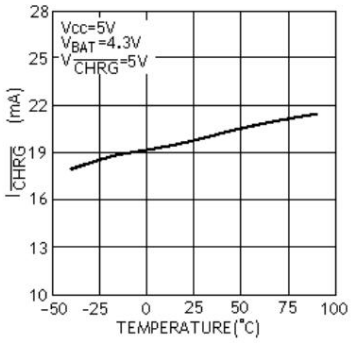


Pin in weak pull-down state CHRG

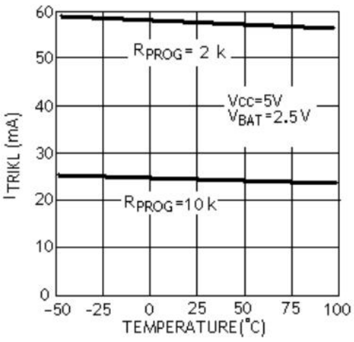
IV curve



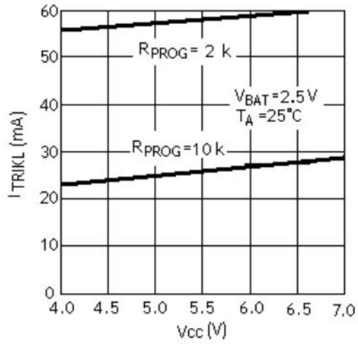
The relationship between pin current and $\overline{CHRG}$ temperature in weak pull-down state



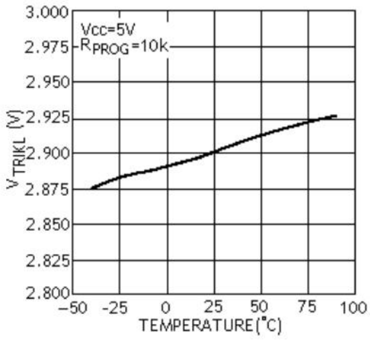
The relationship between trickle charging current and temperature. curve



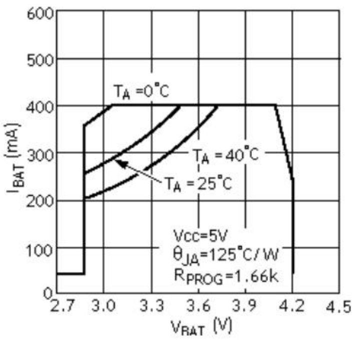
The relationship between trickle charging current and power supply voltage. Relationship lines



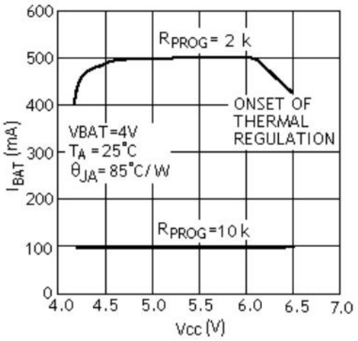
Trickle Charge Threshold vs. Temperature



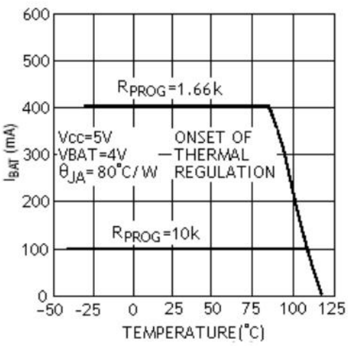
Charging Current vs. Battery Voltage Curve curve



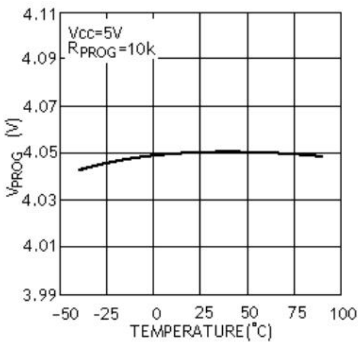
The relationship between charging current and power supply voltage curve



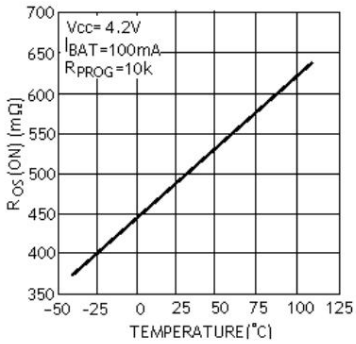
Charging current versus ambient temperature curve



Recharge Voltage Threshold vs. Temperature Curve



Power FET "on" resistance and temperature degree relationship curve



Pin function

CHRG (Pin 1): Open-drain charge status output. During battery charging, an internal **N-** channel **MOSFET** pulls the **CHRG** pin low. When the charge cycle ends, a weak pull-down current source of approximately 20μA is connected to the CHRG pin, indicating an "AC present" condition. When **the TP4054** detects an undervoltage lockout **condition, the CHRG** pin is forced to a high-impedance state.

GND (Pin 2): Ground BAT

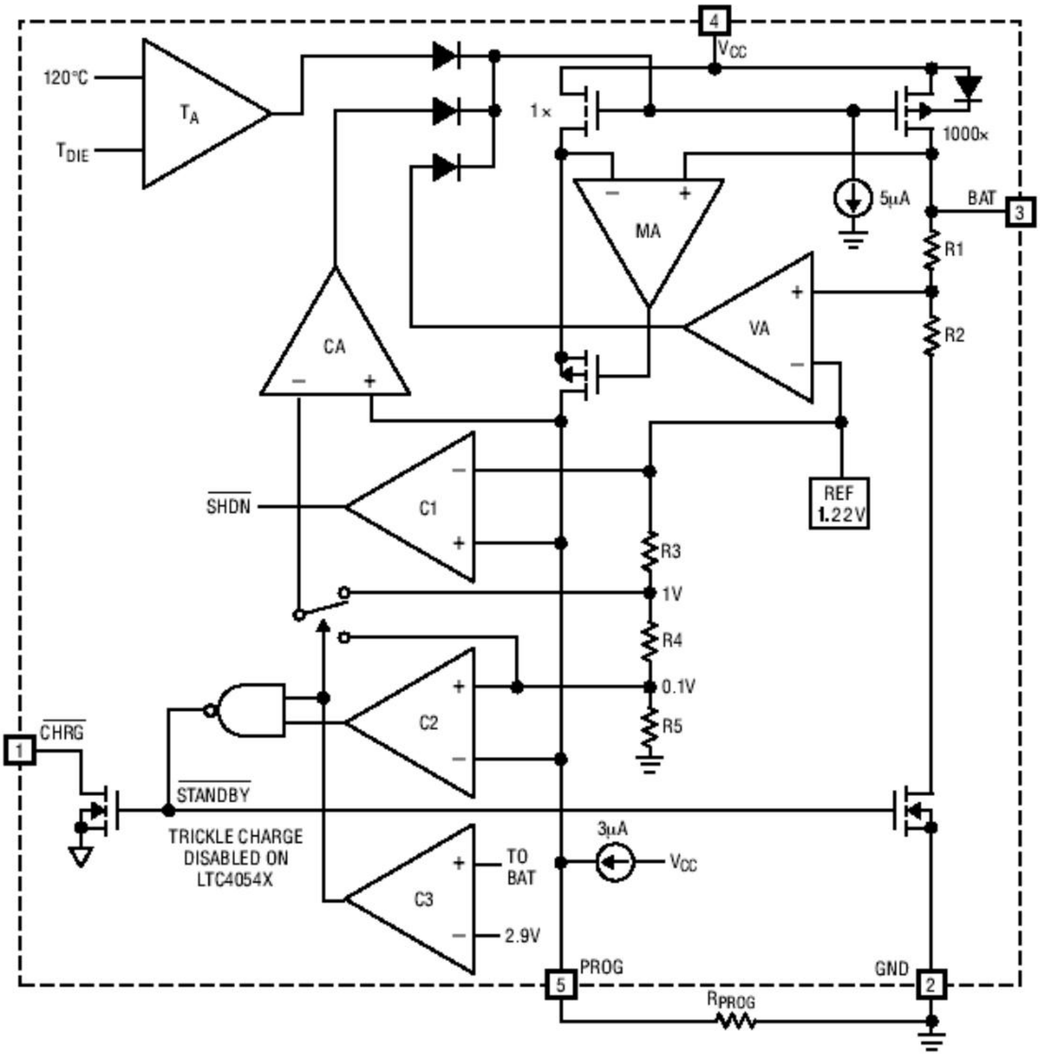
(Pin 3): Charging current output. This pin provides charging current to the battery and regulates the final float voltage to 4.2V. A precision internal resistor divider on this pin sets the float voltage, and in shutdown mode, the internal resistor divider is disconnected.

VCC (Pin 4): Positive input supply voltage. This pin **supplies power to the charger. VCC varies** between **4V** and **9V** time and should be bypassed with at least a 1μF capacitor. When **VCC drops to** within **30mV** of **the BAT** pin voltage , **the TP4054** enters shutdown mode, causing **IBAT to drop** below 2ÿA .

PROG (Pin 5): Charging current setting, charging current monitoring and shutdown pin. Connecting a 1% resistor **RPROG** between this pin and ground sets the charging current. When charging in constant current mode, the voltage at the pin is maintained at **1V.**

The **PROG** pin can also be used to shut down the charger. Disconnect the setting resistor from ground, and an internal **2.5ÿA** current pulls the **PROG** pin high. When the voltage on this pin reaches the shutdown threshold voltage of **2.70V ,** the charger enters shutdown mode, charging stops and the input supply current drops to 45ÿA. Reconnecting RPROG to ground will restore the charger to normal operation.

block diagram



working principle

TP4054 is a constant current/constant voltage circuit French single-cell lithium-ion battery charger. it can provide **800mA** charging current (with the help of a well-thermally designed **PCB** layout) and an internal **P-** channel power **MOSFET** and thermal regulation circuitry. No isolation diode or external current sense required sensing resistor; therefore, the base charger circuit requires only two external components. Not only that, TP4054 can also convert from a **The USB** power supply obtains working power.

Normal charging cycle

When **the Vcc** pin voltage rises to **the UVLO** threshold level and on and **a** precision setting resistor for 1% or when a battery with charger input When the terminals are connected, a charging cycle begins. If **BAT** If the pin level is lower than 2.9V, the charger will enter trickle charging. model. In this mode, the TP4054 provides approximately **1/10** of the Set the charging current to increase the current and voltage to a safe level, thereby achieving full current charging.

When **the BAT** pin voltage rises above **2.9V ,** charging The device enters constant current mode, providing a constant current to the battery. recharging current. When **the BAT** pin voltage reaches the final float charge voltage (4.2V), TP4054 enters constant voltage mode. And the charging current begins to decrease. When the charging current drops to the set value 1/10 , the charging cycle ends.

Charging current setting

The charging current is drawn using a connection between **the PROG** pin and ground resistor between them. Set the resistor and charging voltage Flow is calculated using the following formula:

Determine the resistor resistance according to the required charging current,

Formula 1: $$R_{PROG} = \frac{1000}{I_{ONE}} \times \left(1.2 - \frac{4}{3} I_{ONE}\right)$$

(IBAT >0.15A)

Formula 2: $$R_{PROG} = \frac{1000}{I_{ONE}}$$ **(IBAT ≤0.15A)**

Example 1: When the charging current needs to be set to IBAT=0.4A , Calculated using formula 1:

$$RPROG = \frac{1000}{0.4} \times \left(1.2 - \frac{4}{3} \times 0.4\right) = 1666 \quad \text{(Oh)}$$

That is **RPROG=1.66kΩ**

Example 2: When the charging current needs to be set to IBAT=0.1A , Calculated using formula 2:

$$R_{PROG} = \frac{1000}{I_{ONE}} = \frac{1000}{0.1} = 10000 \quad \text{(Oh)}$$

That is RPROG=10kΩ

Charging terminated

When the charging current drops after reaching the final float voltage When reaching **1/10** of the set value , the charging cycle is terminated. This article part is achieved by using an internal filtered comparator on **the PROG** The pin is monitored for detection. When **the PROG** pin voltage The time for falling below **100mV** exceeds ***t*** $_{TERM}$ (generally 1.8ms), charging is terminated. The charging current is blocked, TP4054 enters standby mode, and the input power current drops to 45μA. (Note: C/10 terminates at trickle charge and thermal limit disabled in control mode).

While charging, a transient load on the BAT pin causes **The PROG** pin voltage drops to the set value when **the DC** charging current 1/10 briefly drops below 100mV. Terminate comparison The 1.8ms filter time (t_{TERM}) on the controller ensures this Qualitative load transients will not cause premature termination of the charge cycle. one Once the average charging current drops below 1/10 of the set value, **TP4054** terminates the charge cycle and stops passing the BAT pin supply any current. In this state, the BAT pin All loads must be powered by batteries. In standby mode,

TP4054 responds to **the BAT** pin voltage Perform continuous monitoring. If the voltage on this pin drops to 4.05V the below ***the recharge threshold (VRECHRG),*** the other charging The cycle begins and current is supplied to the battery again. When in standby mode When performing a manual restart of the charging cycle in the formula, it must be canceled Then the input voltage is applied again, or the charger must be turned off and Use **PROG** pin for restart. Figure 1 shows a State diagram of a typical charging cycle.

Charging status indicator ( ) $\overline{\text{CHRG}}$

The charge status output has three different states: strong down pull-up (approximately 10mA), weak pull-down (approximately 20μA), and high impedance. A strong pull-down state indicates that **the TP4054** is in a charge cycle middle. Once the charge cycle is terminated, the pin status changes from undervoltage to Determined by blocking conditions. A weak pull-down state indicates that Vcc satisfies **UVLO** condition and **the TP4054** is in charge-ready state. high impedance state indicates that **the TP4054** is in undervoltage lockout mode: To Why **Vcc** is less than 100mV higher than **the BAT** pin voltage?

Either the voltage applied to the **Vcc** pin is insufficient. A microprocessor can be used to distinguish between these three states - this method is discussed in the "Application Information" section.

thermal limit

If the chip temperature attempts to rise above a preset value of approximately 100°C, an internal thermal feedback loop will reduce the set charging current until charging stops above 140°C. This feature prevents **the TP4054** from overheating and allows the user to increase the upper limit of a given board's power handling capabilities without the risk of damaging **the TP4054 .** The charging current can be set based on typical (rather than worst-case) ambient temperatures, while ensuring that the charger will automatically reduce current under worst-case conditions. related **ThinSOT** power considerations are further discussed in the Applications Information section.

Undervoltage lockout

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 will keep the charger in shutdown mode. If **the UVLO** comparator trips, the charger will not exit shutdown mode until **Vcc** rises **100mV** above the battery voltage.

Manual shutdown

The TP4054 can be placed in shutdown mode at any time during the charge cycle by removing **RPROG (thereby** floating the **PROG** pin) . This reduces battery leakage current to less than 2ÿA and supply current to less than 50ÿA . Reconnecting the setting resistor initiates a new charge cycle.

In manual shutdown mode, the **CHRG** pin is weakly pulled down whenever **Vcc** is high enough to exceed **the UVLO** condition. If the TP4054 is in undervoltage lockout mode, **the CHRG** pin is in a high-impedance state: either Vcc is less than 100mV above the BAT pin voltage, or there is insufficient voltage applied to the Vcc pin.

automatic restart

Once the charge cycle is terminated, the TP4054 immediately adopts A filter time of 1.8ms ($t_{RECHARGE}$ the ratio of comparator to continuously monitor the voltage on the BAT pin. When the battery voltage drops below 4.05V (roughly corresponding to 80% to 90% of the battery's capacity), the charging cycle begins again. This ensures that the battery is maintained at (or close to) a full state of charge and eliminates the need for periodic charge cycle initiation. During the recharge cycle, the CHRG pin output

Enter a strong pull-down state.

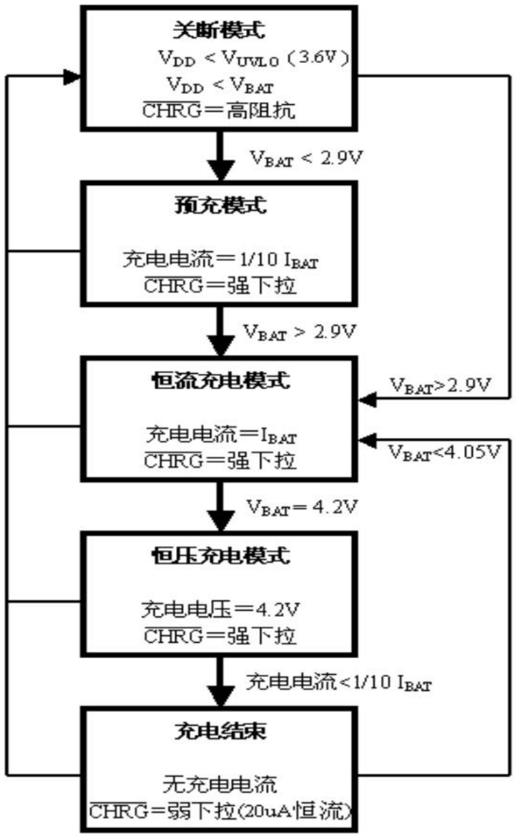


Figure 1: State diagram of a typical charging cycle: State diagram of a typical charging cycle

Stability considerations

As long as the battery is connected to the charger's output, the constant-voltage mode feedback loop remains stable with an external capacitor. In order to reduce the ripple voltage when the battery is not connected, it is recommended to use an output capacitor. When using large value low **ESR** ceramic capacitors, it is recommended to add a 1ÿ resistor in series with the capacitor . If tantalum capacitors are used, no series resistor is required.

In constant current mode, it is the **PROG** pin that is in the feedback loop, not the battery. Constant current mode stability is affected by **the PROG** pin impedance. No additional capacitor on the **PROG** pin will reduce the maximum allowable resistance of the set resistor. The pole frequency on the PROG pin should remain at CPROG, then the following formula can be used to calculate the maximum resistance value of **RPROG :**

$$R_{PROG} \leq \frac{1}{2\pi \cdot 10^{5} \cdot C_{PROG}}$$

For users, they may be more interested in charging current rather than transient current. For example, if a switching power supply operating in low current mode is connected in parallel with a battery, then the

The average current flowing out of **the BAT** pin is typically smaller than the transient current pulse

Rushing is more important. In this case, the **PROG** pin can

A simple RC filter is used to measure the average electrical

Cell current (shown in Figure **2).** on the **PROG** pin and filter

A **10k** resistor is added between the capacitors to ensure stable

Qualitative.

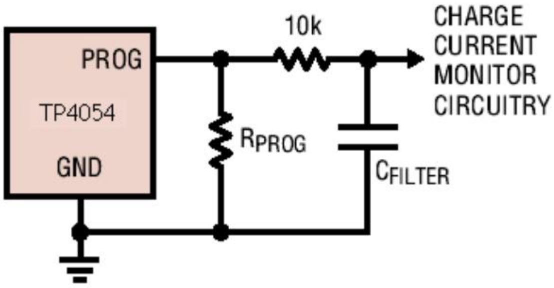


Figure 2: Capacitive load on isolated **PROG** pin

and filter circuit

Power loss

TP4054 reduces charging current due to thermal feedback

The condition can be estimated from the power loss in **the IC .** This kind of

Almost all power losses are generated by the internal **MOSFET**

- This can be approximated by the following formula:

$$P_D = (V_{CC} ÿ V_{ONE}) \cdot I_{ONE}$$

PD in the formula is the dissipated power, VCC is the input power supply voltage

voltage, VBAT is the battery voltage, and IBAT is the charging current. When hot

When feedback begins to protect **the IC ,** the ambient temperature is approximately:

$$TA = 120° C ÿ P_D \theta_{AND}$$

$$T_A = 120°C ÿ (V_{CC} ÿ V_{ONE}) \cdot I_{ONE} \cdot \theta_{AND}$$

Example: Programming a device to work from a **5V USB** power supply

The TP4054 as a power supply supplies an amplifier with a voltage of **3.75V .**

Lithium-ion battery provides **400mA** full amplitude current. hypothesis

θ_{JA} *is* 150°C/W (see board layout considerations),

When **TP4054** starts to reduce the charging current, the ambient temperature is close to

Looks like:

$$TA = 120°C ÿ (5V ÿ 3.75V) \cdot (400mA) \cdot 150°C/W$$

$$TA = 120°C ÿ 0.5 W \cdot 150°C/W = 120°C ÿ 75°C$$

$$TA = 45°C$$

TP4054 can be used under ambient temperature conditions above 45ÿ

used, but the charging current will be reduced to less than **400mA .** for

For a given ambient temperature, the charging current can be approximated by the following formula

Find:

$$I_{ONE} = \frac{120°C - T_A}{(V_{CC} - V_{ONE}) \cdot \theta_{AND}}$$

Consider the previous example again with an ambient temperature of 60°C. Charge

The electrical current will be reduced to approximately:

$$I_{ONE} = \frac{120°C - 60°C}{(5V - 3.75V) \cdot 150°C/W} = \frac{60°C}{187.5°C/A}$$

$$I_{ONE} = 320 mA$$

Not only that, as discussed in the How It Works section,

When thermal feedback causes the charging current to decrease, the PROG pin

The voltage will also decrease proportionally.

Remember that there is no need to consider the most important factors in **TP4054** application design

bad thermal conditions, this is important because the **IC** will be in

The power consumption is automatically reduced when the junction temperature reaches about 120ÿ.

Thermal

Considerations Due to the small form factor of the **SOT23-5** package,

Therefore, a well-designed thermally designed **PC** board layout is required to

Maximize the usable charging current, which is very

Very important. Thermal pass used to dissipate the heat generated by **the IC**

path from the chip to the lead frame and through the peak rear leads (special

(especially the ground lead) reaches the copper surface **of the PC** board. PC board copper surface

for the radiator. The copper foil area where the pins are connected should be as wide as possible

wide and extending outward to a larger copper area to transfer heat

spread into the surrounding environment. to internal or back copper circuit layers

Vias also play a significant role in improving the overall thermal performance of the charger.

Useful. When doing **PC** board layout design, the circuit board

Other heat sources unrelated to the charger must also be considered.

considerations as they will affect the overall temperature rise and maximum charging current

have an impact.

The table below lists several different circuit board sizes and copper surfaces

Thermal resistance under accumulation conditions. All measurements are at rest

3/32ÿ FR-4 circuit board in air (the device is mounted on it

top surface) obtained.

表 1：实测热阻 (双层电路板*)

铜面积		电路板面积	结点至环境热阻
顶面	底面		
2500mm²	2500mm²	2500mm²	125°C/W
1000mm²	2500mm²	2500mm²	125°C/W
225mm²	2500mm²	2500mm²	130°C/W
100mm²	2500mm²	2500mm²	135°C/W
50mm²	2500mm²	2500mm²	150°C/W

*每层采用 1 盎司铜箔

表 2：实测热阻 (四层电路板**)

铜面积 (每面)	电路板面积	结点至环境热阻
2500mm²***	2500mm²	80°C/W

** 顶层和底层采用 2 盎司铜箔，内层采用 1 盎司铜箔。
*** 总铜面积为 10,000mm²

Increase thermal regulation current

Reducing the voltage drop across the internal **MOSFET** can significantly Reduce power consumption in **IC .** During thermal regulation, this has increased The effect of increasing the current delivered to the battery. One of the countermeasures is to pass An external component (such as a resistor or diode) will Some of the power is dissipated.

Example: Programming a **5V** AC adapter from To obtain operating power **the TP4054** supplies a **3.75V** Voltage discharge lithium-ion battery provides **800mA** full charge current. Assuming that ***JA is* 125ÿ/W, in** an environment of 25ÿ Under temperature conditions, the charging current is approximately:

$$I_{ONE} = \frac{120^{\circ}C - 25^{\circ}C}{(5V - 3.75V) \cdot 125^{\circ}C/W} = 608\ mA$$

By lowering a resistor in series with the **5V** AC adapter The voltage at both ends (as shown in Figure **3)** can reduce on-chip power consumption, Thereby increasing the thermally adjusted charging current:

$$I_{ONE} = \frac{120^{\circ}C - 25^{\circ}C}{(V_S - I_{BAT} R_{CC} - V_{BAT}) \cdot \mathrm{i}_{AND}}$$

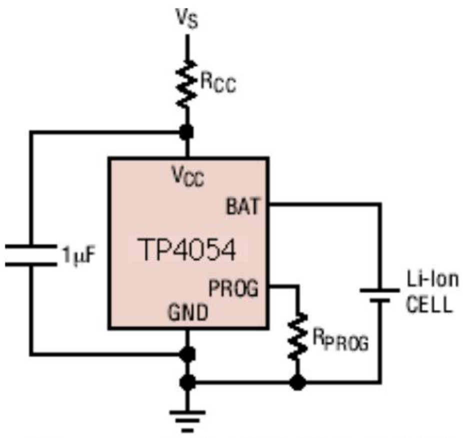


图 3：一种能尽量增大热调节模式充节电流的电路

Using the quadratic equation we can find I_{ONE} ÿ

$$I_{ONE} = \frac{(V_{WITH} - V_{BAT}) - \sqrt{(V_{WITH} - V_{BAT})^2 - \frac{4R_{CC}(120^{\circ}C - T_A)}{\mathrm{i}_{AND}}}}{2R_{CC}}$$

ÿ **RCC=0.25ÿÿVS=5VÿVBAT=3.75VÿTA=25ÿ**

and i_{AND} = 125ÿ/W , we can calculate the thermal adjustment The charging current:

IBATÿ708.4mA

Although this application can input power to the battery in thermal trim mode Send more energy and shorten charging time, but in voltage mode , if VCC becomes low enough that **the TP4054** is in a low voltage drop condition, it may actually extend the charging time. Figure 4 shows how this circuit behaves as RCC becomes larger. due to voltage drop.

When in order to keep component size small and avoid the occurrence of This technology works best when minimizing the RCC value due to voltage drop . role. Remember to choose a system with sufficient power handling capabilities force resistor.

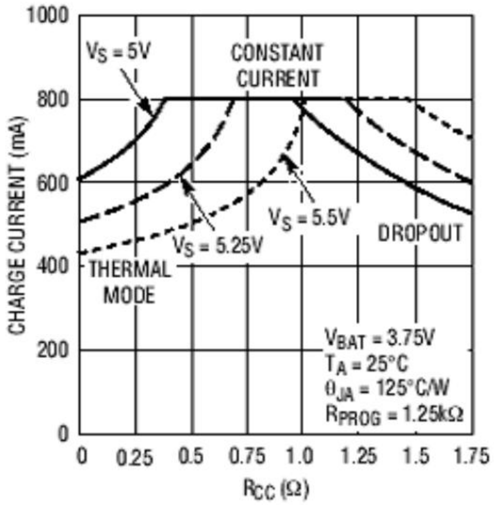


图 4：充电电流与 RCC 的关系曲线

VCC bypass capacitor

Several types of capacitors can be used for input bypass. Ran However, caution must be used when using multilayer ceramic capacitors. because Some types of ceramic capacitors have self-resonance and high Q values characteristics, therefore, under certain starting conditions (such as charging The electrical input is connected to a working power supply) it is possible to Generates high voltage transient signals. Add a ceramic battery with X5R A 1.5ÿ resistor in series with the container will minimize Start voltage transient signal.

Charging current soft start

The TP4054 includes a Soft-start circuitry that minimizes inrush current. When one When a charging cycle is started, the charging current will be around 20ÿs The time on the right rises from 0 to full full scale value. at startup process, this can minimize the impact on the power supply Effect of transient current loads.

$\overline{CHRG}$ status output pin

The CHRG pin provides an indication that the input voltage is above the undervoltage lockout threshold level. A weak pull-down current of approximately 20µA indicates that sufficient voltage is applied to the **VCC** pin to begin the charge cycle. When a discharged battery is connected to the charger, the constant current portion of the charge cycle begins and the **CHRG** pin is pulled to ground. The CHRG pin is capable of sinking up to 10mA to drive an LED that indicates a charge cycle is in progress. When

the battery is nearly full, the charger enters the constant voltage portion of the charge cycle and the charge current begins to decrease. When the charging current drops to less than 1/10 of the set current, the charging cycle ends and the strong pull-down is replaced by a 20ÿA pull-down, indicating that the charging cycle has ended. If the input voltage is removed or drops below the undervoltage lockout threshold, the CHRG pin becomes high impedance. Using two pull-up resistors of different values, a microprocessor can detect all three states from this pin, as shown in Figure 5.

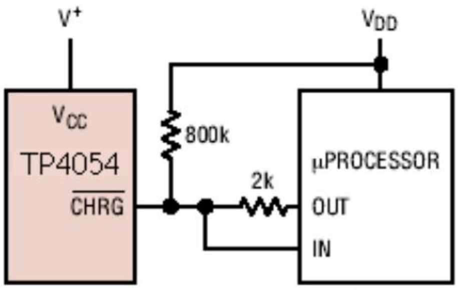


Figure 5: Using a microprocessor to determine pin status Using a microprocessor to determine $\overline{CHRG}$ pin status

To **detect** when **the TP4054** is in charging mode, force the digital output pin (OUT) high and measure the voltage on the **CHRG** pin. Even with a 2k pull-up resistor, the N- channel **MOSFET** will pull this pin low. Once the charge cycle is terminated, the N-channel **MOSFET** is turned off and a 20µA current source is connected to the CHRG pin. The IN pin will then be pulled high by the 2K pull-up resistor. To determine if a weak pull-down current is present, the OUT pin should be forced into a high-impedance state. A weak current source will pull the IN pin low through an 800K resistor; if the CHRG pin is high impedance, the IN pin will be pulled high, indicating that the device is in a **UVLO** state.

Reverse polarity input voltage protection

In some applications, reverse polarity voltage protection on VCC is required. If the supply voltage is high enough, a series isolation diode can be used. In other situations where the voltage drop must be kept low, a **P-** channel **MOSFET can be used (as** shown in Figure 6).

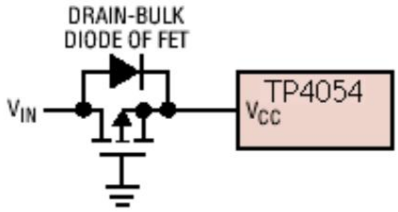


图 6：低损耗输入反向极性保护

USB and AC adapter power

The TP4054 allows charging from an AC adapter or a **USB** port. Figure **7** shows an example of how to combine an AC adapter with **a USB** power input. A **P-** channel **MOSFET (MP1) is used to prevent** reverse flow of signals into **the USB** port when the AC adapter is plugged in, and a Schottky diode (D1) is used to prevent **USB** power from passing through **the 1K** pull-down resistor. produce losses.

Generally speaking, AC adapters are capable of delivering much more current than **USB** ports, which have a current limit of **500mA .** Therefore, when the AC adapter is connected, an **N-** channel **MOSFET (MN1) and an additional 10K** setting resistor can be used to increase the charging current to **600mA.**

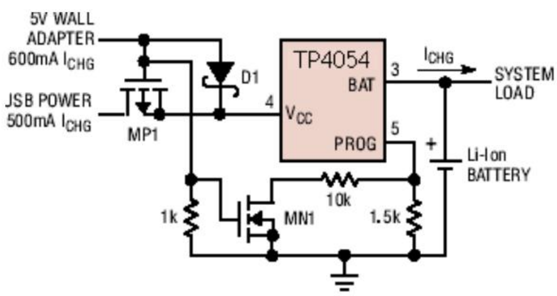
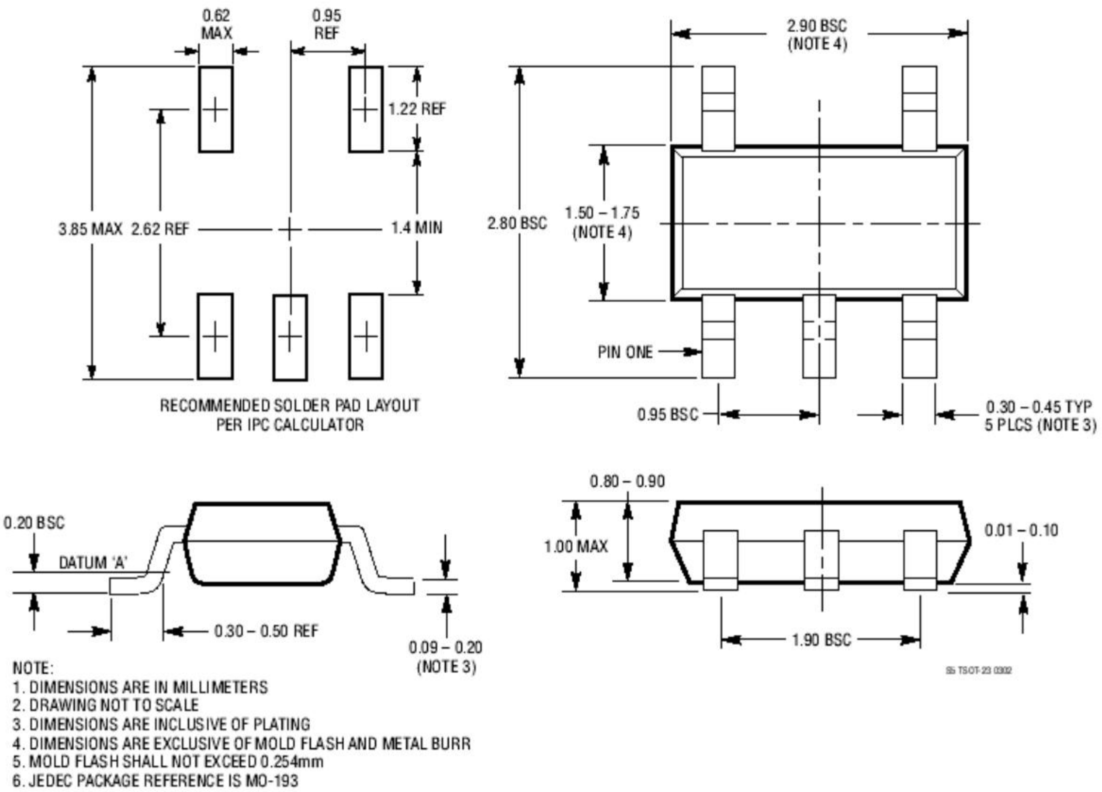


图 7：交流适配器与 USB 电源的组合

Package description

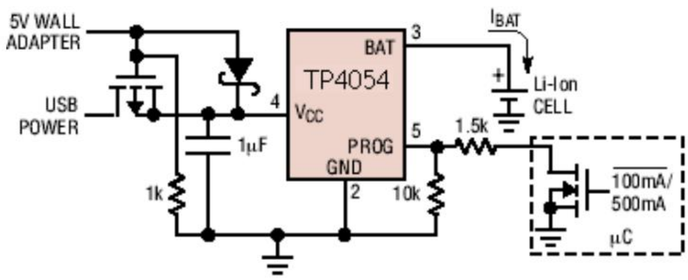
S5

package **5-** lead plastic **SOT-23-5** package

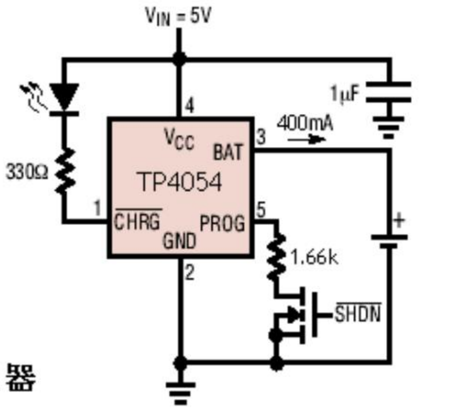


typical application

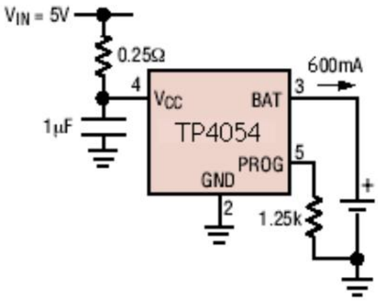
USB/交流适配器电源锂离子电池充电器



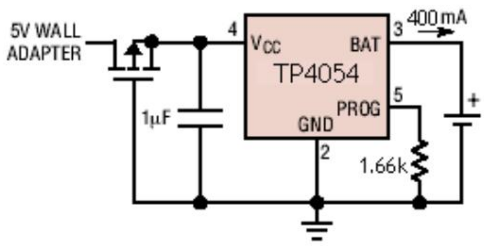
全功能单节锂离子电池充电器



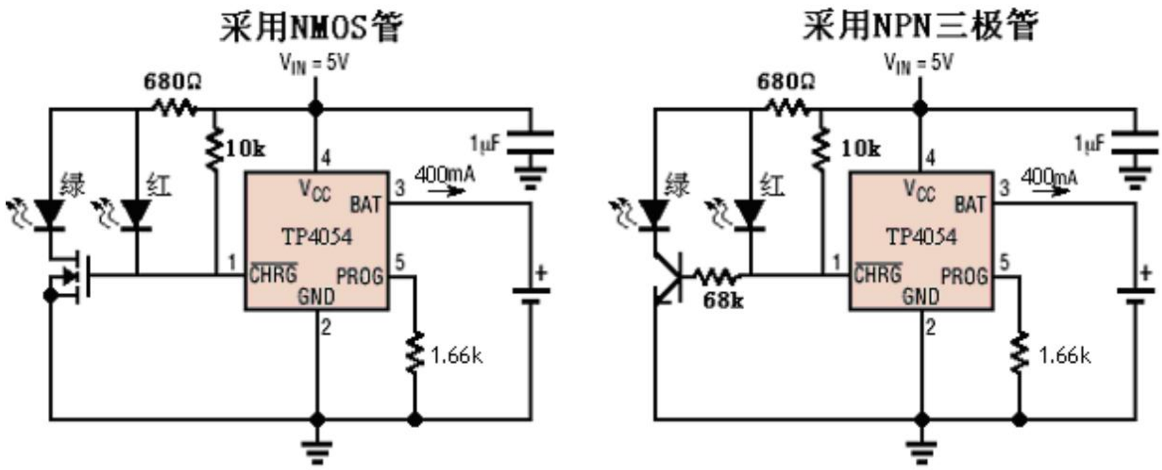
采用外部功率耗散的600mA锂离子电池充电器



具有反向极性输入保护功能的基本锂离子电池充电器



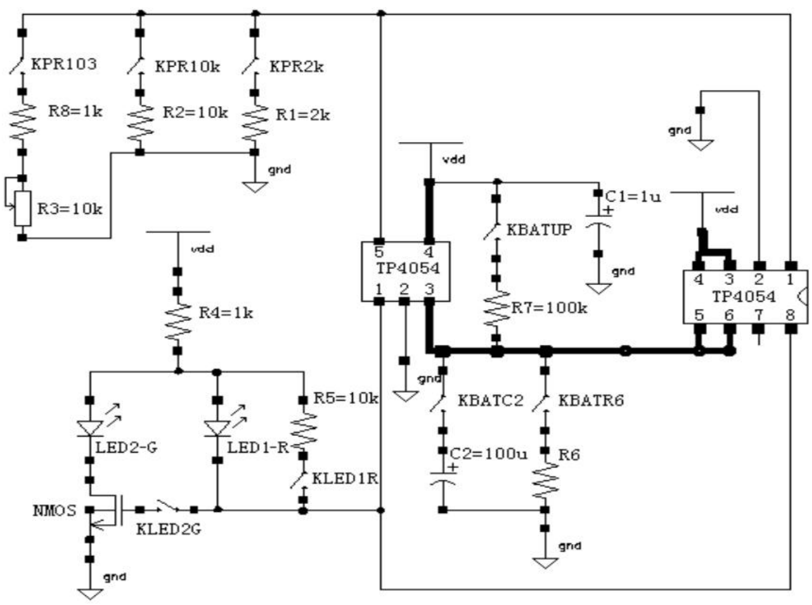
红绿灯控制电路



Note: In normal charging status, the red light is on and the green light is off. After charging is completed, the red light goes out and the green light turns on.

TP4054 usage precautions and **DEMO** board instructions

1. TP4054 DEMO board circuit diagram



2. Function demonstration description: (Working environment: power supply voltage 5V, working temperature 25ÿ.)

1. Set the charging current.

Close **KPR2k, RPROG=2k** close **KPR10k,** **350mA**

RPROG=10k close **KPR2k, KPR10k,** **100mA**

RPROG=1.66k 400mA close **KPR103, RPROG=1k-11k** 2. Set the indicator light

100mA-450mA (due to thermal limitations, the current becomes smaller)

Only red light indicates: disconnect **KLED1R,** KLED2G. At this time, the red light has three states: high brightness, weak brightness, and off. Highlight: Currently Charging; weak light: charging completed; off: fault status (power supply voltage is insufficient, etc.). If the customer only needs The red light has two states: on and off. You need to close **KLED1R and connect** R5. At this time, the red light is on: charging;

Off: Charging is completed.

Red and green double light indication: close **KLED1R, KLED2G** red

light is on, green light is off: charging is in progress; red light is off, green light is on: charging is completed.

3. Simulate charging status

Close **the KPR10k, KLED1R, KLED2G, KBATC2, KBATR6 BAT** terminal and connect

a capacitor **C2** and a resistor **R6** instead of the lithium battery to simulate the charging state: the red light is on and the green light is off.

Note: This state simulation is limited to power supply voltages less than or equal to 5V. If it is greater than **5V ,** please use a lithium battery for testing.

Close **the KPR10k, KLED1R, KLED2G, KBATC2 BAT** terminal and

connect a capacitor **C2** instead of the lithium battery to simulate the charging completion state: the green light is on and the red light is off.

Note: Since the **100uF** capacitor **C2** is used instead of the lithium battery to simulate the full state, the capacitor slowly discharges when it is full.

When the voltage drops to the recharge threshold voltage **4.05V ,** it will automatically recharge and you can see the red light flashing periodically.

4. Analog charging terminal **BAT** terminal voltage

Close **KPR10k, KLED1R, KLED2G, KBATC2, KBATR6** to measure **the BAT** terminal

voltage. That is, the voltage at the end of charging is **4.2V** ±1%.

5. In order to avoid the unstable status of the indicator light when there is no lithium battery on **the BAT** end of the customer's application, close **KBATUP and** use **100k** on **the BAT** end.

The resistor is connected to Vdd, and the green light is on to indicate the standby state.

6. Lithium battery charging

Connect the positive electrode of the lithium battery to the **BAT** terminal of the chip and the negative electrode to ground. Set the required charging current and indicator light,

disconnect **KBATC2 and** KBATR6, and start charging.

Third attachment: The relationship between charging current and set resistance is measured data **of DEMO** board.

Test conditions: Ambient temperature: 25ÿ **Power supply voltage: Vcc=5V Battery voltage: Vbat=3.8V (750MAH)**

Rprog(ÿ)	Theoretical value (mA)	Actual measurement value (mA)							
		No. 1 piece	No. 2 **piece**	No. **3** piece	No. **4** piece	No **5** piece	**6** piece		
1.66k	**400**	**400**	**410**	**410**	**405**	**405**	**410**	**405**	**400**
2k	**360**	**350**	**370**	**370**	**365**	**365**	**370**	**370**	**355**
2.5k	**313**	**320**	**325**	**320**	**310**	**320**	**325**	**330**	**320**
3.33k	**255**	**260**	**260**	**260**	**255**	**255**	**260**	**255**	**250**
5k	**190**	**190**	**190**	**190**	**180**	**185**	**190**	**185**	**182**
10k	**100**	**104**	**107**	**111**	**100**	**100**	**105**	**108**	**100**

(Note: Part of the current reduction under high current conditions is affected by temperature modulation. It is recommended that customers refer to the data in the above table to select the **Rprog** size in actual use)