## 描述 / Descriptions

BRCL4054ME是一款完整的单节锂离子电池采用恒定电流/恒定电压线性充电器。其SOT封装与较少的外部元件数目使得BRCL4054ME成为便携式应用的理想选择。BRCL4054ME可以适合USB电源和适配器电源工作。

The BRCL4054ME is a complete constant-current/constant voltage linear charger for single cell lithium-ion batteries. Its ThinSOT package and low external component count make the BRCL4054ME ideally suited for portable applications. Furthermore, the BRCL4054ME is specifically designed to work within USB power specifications.

由于采用了内部PMOSFET架构，加上防倒充电路，所以不需要外部检测电阻器和隔离二极管。热反馈可对充电电流进行调节，以便在大功率操作或高环境温度条件下对芯片温度加以限制。充电电压固定于4.2V，而充电电流可通过一个电阻器进行外部设置当充电电流在达到最终浮充电压之后降至设定值1/10时，BRCL4054ME将自动终止充电循环。

No external sense resistor is needed, and no blocking diode is required due to the internal MOSFET architecture. Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature. The charge voltage is fixed at 4.2V, and the charge current can be programmed externally with a single resistor. The BRCL4054ME automatically terminates the charge cycle when the charge current drops to 1/10th the programmed value after the final float voltage is reached.

当输入电压（交流适配器或USB电源）被拿掉时，BRCL4054ME自动进入一个低电流状态，将电池漏电流降至2uA以下。也可将BRCL4054ME置于停机模式，以而将供电电流降至25uA。
BRCL4054ME的其他特点包括充电电流监控器、欠压闭锁、自动再充电和一个用于指示充电结束和输入电压接入的状态引脚。

When the input supply (wall adapter or USB supply) is removed, the BRCL4054ME automatically enters a low current state, dropping the battery drain current to less than 2μA. The BRCL4054ME can be put into shutdown mode, reducing the supply current to 25μA. Other features include charge current monitor, under voltage lockout, automatic recharge and a status pin to indicate charge termination and the presence of an input voltage.

## 特征 / Features

- 高达800mA的可编程充电电流
  Programmable Charge Current Up to 800mA
- 无需MOSFET、检测电阻器或隔离二极管
  No MOSFET, Sense Resistor or Blocking Diode Required
- 用于单节锂离子电池、采用SOT23-5封装的完整线性充电器
- Complete Linear Charger in 5-Lead SOT-23 Package for Single Cell Lithium-Ion Batteries
- 恒定电流/恒定电压操作，并具有热调节功能
  Constant-Current/Constant-Voltage Operation with Thermal Regulation to Maximize Charge Rate Without Risk of Overheating
- 直接从USB端口给单节锂离子电池充电
  Charges Single Cell Li-Ion Batteries Directly from USB Port
- 4.2V预设充电电压
  Preset 4.2V Charge Voltage with ±1% Accuracy
- 用于电池电量检测的充电电流监控器输出
  Charge Current Monitor Output for Gas Gauging
- 自动再充电
  Automatic Recharge

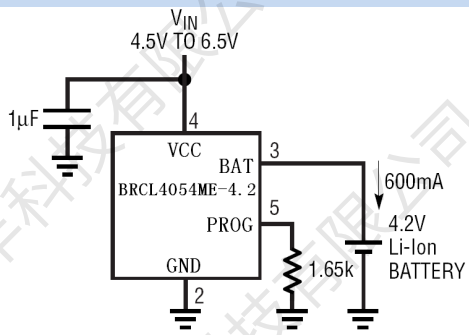
## 特征 / Features

- 充电状态输出引脚
  Charge Status Output Pin
- C/10充电终止
  C/10 Charge Termination
- 待机模式下的供电电流为25μA
  25μA Supply Current in Shutdown
- 2.9V涓流充电器件版本
  2.9V Trickle Charge Threshold
- 软启动限制了浪涌电流
  Soft-Start Limits Inrush Current
- 单灯使用时，充满后灯正在消失。
  When using a single lamp, the light is fading after fully charging.

## 用途 / Applications

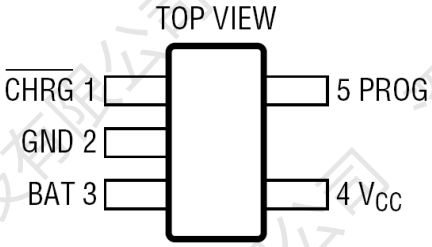
- 蜂窝电话、PDA、MP3播放器；
  Cellular Telephones, PDAs, MP3 Players
- 充电座
  Charging Docks and Cradles
- 蓝牙应用
  Bluetooth Applications.

## 内部等效电路 / 应用电路　Equivalent Circuit or Application Circuit




## 引脚排列 / Pinning




**$\overline{\text{CHRG}}$ (引脚1):**漏极开路充电状态输出。在电池的充电过程中，由一个内部N沟道MOSFET将$\overline{\text{CHRG}}$引脚拉至低电平。当充电循环结束时，一个约20uA的弱下拉电流源被连接至$\overline{\text{CHRG}}$引脚，指示一个AC存在状态。当BRCL4054ME检测到一个欠压闭锁条件时，$\overline{\text{CHRG}}$引脚被强制为高阻抗状态。

**$\overline{\text{CHRG}}$ (Pin 1):** Open-Drain Charge Status Output. When the battery is charging, the $\overline{\text{CHRG}}$ pin is pulled low by an internal N-channel MOSFET. When the charge cycle is completed, a weak pull-down of approximately 20µA is connected to the $\overline{\text{CHRG}}$ pin, indicating an “AC present” condition. When the BRCL4054ME detects an under voltage lockout condition, $\overline{\text{CHRG}}$ is forced high impedance.

**GND (引脚2):** 地。

**GND (Pin 2)：**Ground.

**BAT (引脚3):**充电电流输出。该引脚向电池提供充电电流并将最终浮充电压调节至4.2V该引脚的一个精准内部电阻分压器设定浮充电压，在停机模式中，该内部电阻分压器断开。

**BAT (Pin 3):**Charge Current Output. Provides charge current to the battery and regulates the final float voltage to 4.2V. An internal precision resistor divider from this pin sets the float voltage which is disconnected in shut down mode.

**$V_{CC}$ ( 引脚4 ) ：**正的输入电源电压。该引脚向充电器供电。$V_{CC}$的变化范围在4.25V-6.5V之间，并应通过至少一个1uF电容器进行旁路。当$V_{CC}$降至BAT引脚电压的30mV以内，BRCL4054ME进入停机模式，从而$I_{BAT}$降至2uA以下。

**$V_{CC}$ (Pin 4):**Positive Input Supply Voltage. Provides power to the charger. $V_{CC}$ can range from 4.25V to 6.5V and should be bypassed with at least a 1µF capacitor. When $V_{CC}$ drops to within 30mV of the BAT pin voltage, the BRCL4054ME enters shutdown mode, dropping $I_{BAT}$ to less than 2µA.

## 引脚排列 / Pinning

**PROG (引脚5):** 充电电流设定，充电电流监控和停机引脚。在该引脚与地之间连接一个精度为1%的电阻器$P_{PRGO}$可以设定充电电流。当在恒定电流模式下进行充电时，该引脚的电压被维持在1V在所有的模式中都可以利用该引脚上的电压来测算充电电流，公式为$I_{BAT}$=（$V_{PROG}$/$R_{PROG}$）*1000.
PROG引脚还可以用来关断充电器。将设定电阻器与地短接，内部一个3.0uA 电流将PROG引脚拉至高电平。当该引脚的电压达到1.21V的停机门限电压时，充电器进入停机模式，充电停止且输入电源电流降至25uA。该引脚还夹约2.4V，电流1.5mA，重新将$R_{PROG}$与地相连将使充电器恢复正常操作状态。

**PROG (Pin 5):**Charge Current Program, Charge Current Monitor and Shutdown Pin. The charge current is programmed by connecting a 1% resistor, $R_{PROG}$, to ground. When charging in constant-current mode, this pin servos to 1V. In all modes, the voltage on this pin can be used to measure the charge current using the following formula: $I_{BAT} = (V_{PROG}/R_{PROG})\times1000$.

The PROG pin can also be used to shut down the charger. Disconnecting the program resistor from ground allows a 3μA current to pull the PROG pin high. When it reaches the 1.21V shutdown threshold voltage, the charger enters shutdown mode, charging stops and the input supply current drops to 25μA. This pin is also clamped to approximately 2.4V. Driving this pin to voltages beyond the clamp voltage will draw currents as high as 1.5mA. Reconnecting $R_{PROG}$ to ground will return the charger to normal operation.

## 印章代码 / Marking

见印章说明。See Marking Instructions

## 极限参数 / Absolute Maximum Ratings(Ta=25℃)(Note 1)

| 参数 Parameter | 数值 Rating | 单位 Unit |
|---|---|---|
| Input Supply Voltage ($V_{CC}$) | -0.3 to 10 | V |
| PROG | -0.3 to $V_{CC}$ + 0.3 | V |
| BAT | -0.3 to 7 | V |
| $\overline{CHRG}$ | -0.3 to 10 | V |
| BAT Short-Circuit Duration | Continuous | |
| BAT Pin Current | 800 | mA |
| PROG Pin Current | 800 | μA |
| Maximum Junction Temperature | 125 | ℃ |
| Operating Ambient Temperature Range(Note 2) | -40~85 | ℃ |
| Storage Temperature Range | -65~125 | ℃ |
| Lead Temperature (Soldering,10sec) | 300 | ℃ |

## 电性能参数 / Electrical Characteristics(Ta=25℃,$V_{CC}$=5V)

| 参数 Parameter | 符号 Symbol | 测试条件 Test Conditions | 最小值 Min | 典型值 Typ | 最大值 Max | 单位 Unit |
|---|---|---|---|---|---|---|
| Input Supply Voltage | $V_{CC}$ | | 4.25 | | 6.5 | V |
| Input Supply Current | $I_{CC}$ | Charge Mode (Note 3), $R_{PROG}$=10k | | 300 | 2000 | μA |
| | | Standby Mode (Charge Terminated) | | 200 | 500 | μA |
| | | Shutdown Mode ($R_{PROG}$ Not Connected $V_{CC}$<$V_{BAT}$, or $V_{CC}$<$V_{UV}$) | | 25 | 50 | μA |
| Regulated Output (Float) Voltage | $V_{FLOAT}$ | 0℃≤$T_A$≤85℃ $I_{BAT}$ =40mA | 4.158 | 4.20 | 4.242 | V |
| BAT Pin Current | $I_{BAT}$ | $R_{PROG}$=10k Current Mode | 93 | 100 | 107 | mA |
| | | $R_{PROG}$=2k Current Mode | 465 | 500 | 535 | mA |
| | | Standby Mode $V_{BAT}$=4.2V | 0 | -2.5 | -6.0 | μA |
| | | Shutdown Mode ($R_{PROG}$ Not Connected) | | ±1.0 | ±2.0 | μA |
| | | Sleep Mode $V_{CC}$ = 0V | | ±1.0 | ±2.0 | μA |
| Trickle Charge Current | $I_{TRIKL}$ | $V_{BAT}$ <$V_{TRIKL}$ $R_{PROG}$=2k | 20 | 45 | 70 | mA |
| Trickle Charge Threshold Voltage | $V_{TRIKL}$ | $R_{PROG}$=10k,$V_{BAT}$ Rising (Note5) | 2.8 | 2.9 | 3.0 | V |
| Trickle Charge Hysteresis Voltage | $V_{TRHYS}$ | $R_{PROG}$ = 10k | 60 | 80 | 110 | mV |

## 电性能参数 / Electrical Characteristics(Ta=25℃)

| 参数 Parameter | 符号 Symbol | 测试条件 Test Conditions | 最小值 Min | 典型值 Typ | 最大值 Max | 单位 Unit |
|---|---|---|---|---|---|---|
| $V_{CC}$ Undervoltage Lockout Threshold | $V_{UV}$ | From $V_{CC}$ Low to High | 3.7 | 3.8 | 3.92 | V |
| $V_{CC}$ Undervoltage Lockout Hysteresis | $V_{UVHYS}$ | | 150 | 200 | 300 | mV |
| Manual Shutdown Threshold Voltage | $V_{MSD}$ | PROG Pin Rising | 1.15 | 1.21 | 1.30 | V |
| | | PROG Pin Falling | 0.9 | 1.0 | 1.1 | V |
| $V_{CC}$ – $V_{BAT}$ Lockout Threshold Voltage | $V_{ASD}$ | $V_{CC}$ from Low to High | 70 | 100 | 140 | mV |
| | | $V_{CC}$ from High to Low | 5.0 | 30 | 50 | mV |
| C/10 Termination Current Threshold | $I_{TERM}$ | $R_{PROG}$=10k (Note4) | 0.085 | 0.10 | 0.115 | mA/mA |
| | | $R_{PROG}$=2k | 0.085 | 0.10 | 0.115 | mA/mA |
| PROG Pin Voltage | $V_{PROG}$ | $R_{PROG}$=10k Current Mode | 0.93 | 1.0 | 1.07 | V |
| $\overline{CHRG}$ Pin Weak Pull-Down Current | $I_{\overline{CHRG}}$ | $V_{CHRG}$=5V | 8.0 | 20 | 35 | μA |
| $\overline{CHRG}$ Pin Output Low Voltage | $V_{\overline{CHRG}}$ | $I_{CHRG}$= 5mA | | 0.35 | 0.60 | V |
| Recharge Battery Threshold Voltage | $V_{RECHRG}$ | $V_{FLOAT}$-$V_{RECHRG}$ | 100 | 150 | 200 | mV |
| Junction Temperature in Constant Temperature Mode | $T_{LIM}$ | | | 120 | | ℃ |
| Power FET “ON” Resistance (Between $V_{CC}$ and BAT) | $R_{ON}$ | | | 600 | | mΩ |
| Soft-Start Time | $t_{SS}$ | $I_{BAT}$=0 to $I_{BAT}$=1000V/$R_{PROG}$ | | 100 | | μs |
| Recharge Comparator Filter Time | $t_{RECHARGE}$ | $V_{BAT}$ High to Low | 0.75 | 2.0 | 4.5 | ms |
| Termination Comparator Filter Time | $t_{TERM}$ | $I_{BAT}$ Falling Below $I_{CHG}$/10 | 400 | 1000 | 2500 | μs |
| PROG Pin Pull-Up Current | $I_{PROG}$ | | | 3.0 | | μA |

Notes:

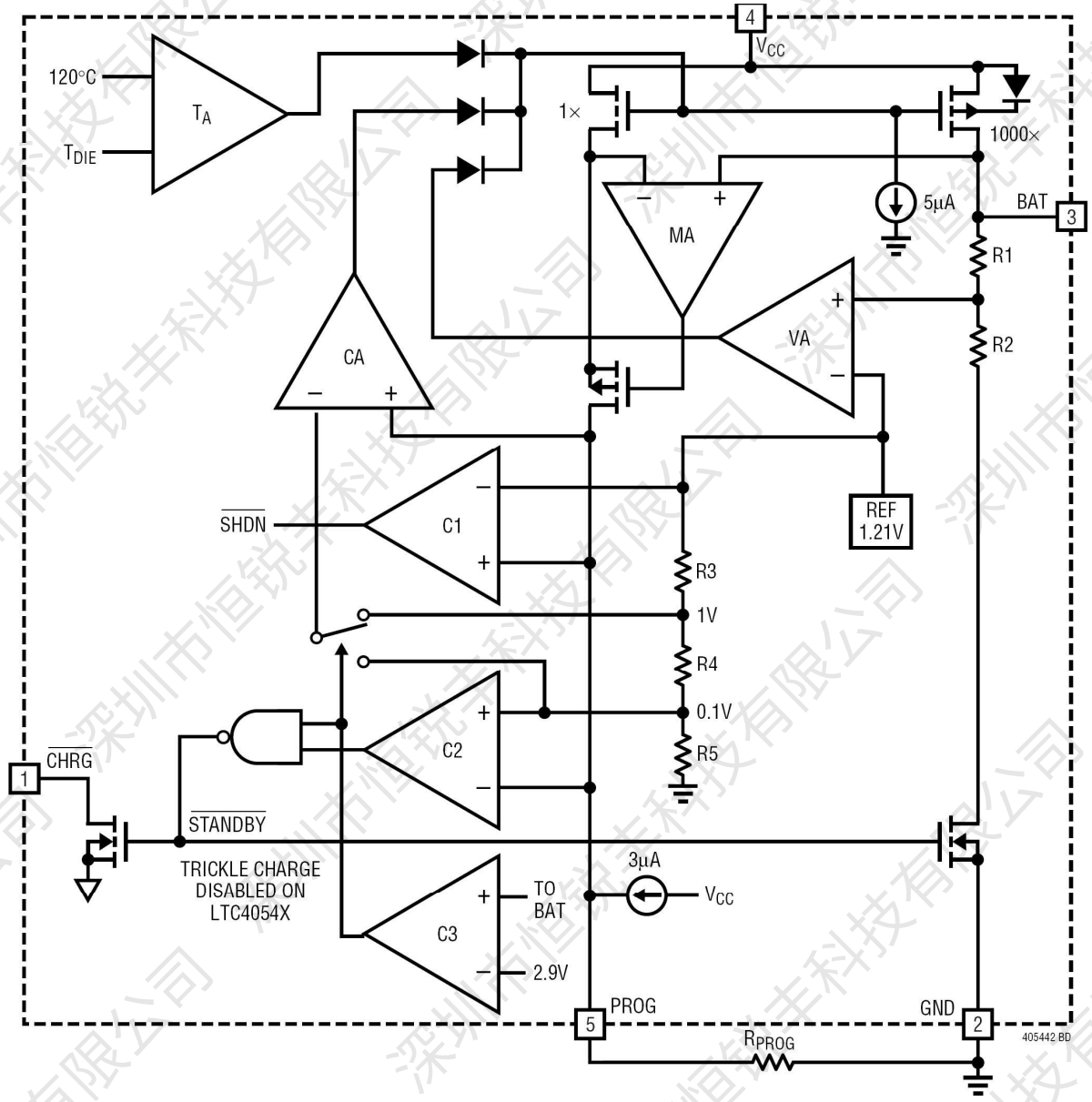
Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

Note 2: The BRCL4054ME-4.2 is guaranteed to meet performance specifications from 0°C to 70°C. Specifications over the –40°C to 85°C operating temperature range are assured by design, characterization and correlation with statistical process controls.

Note 3: Supply current includes PROG pin current (approximately 100μA) but does not include any current delivered to the battery through the BAT pin (approximately 100mA).

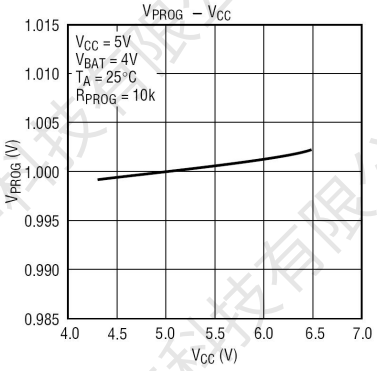
Note 4: $I_{TERM}$ is expressed as a fraction of measured full charge current with indicated PROG resistor.

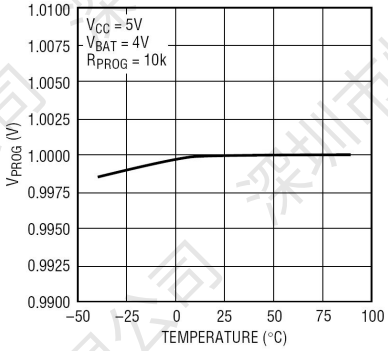
## 原理框图 / Functional Block Diagram



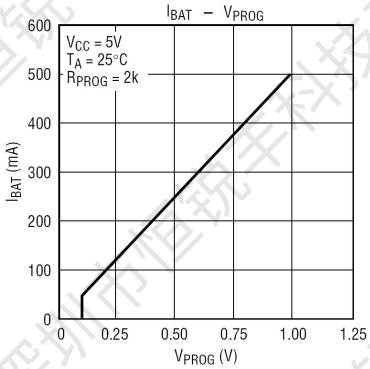
## 电参数曲线图 / Electrical Characteristic Curve

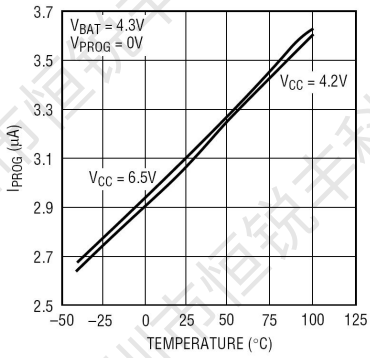
$V_{PROG}$ – $V_{CC}$



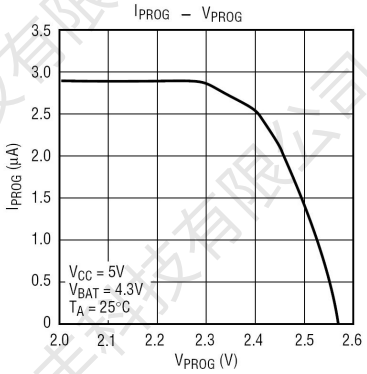




$I_{BAT}$ – $V_{PROG}$

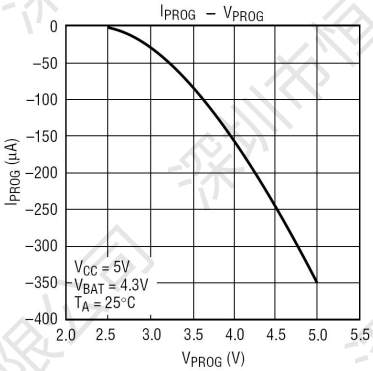


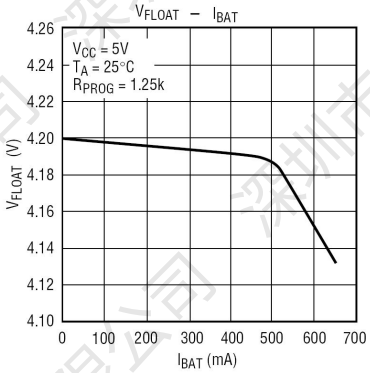

$I_{PROG}$ – $V_{PROG}$

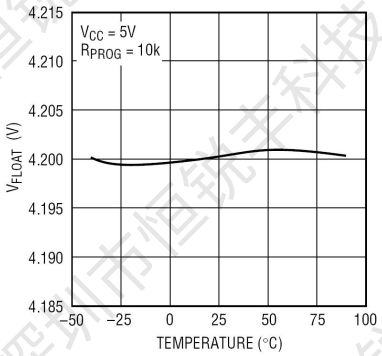



$I_{PROG}$ – $V_{PROG}$

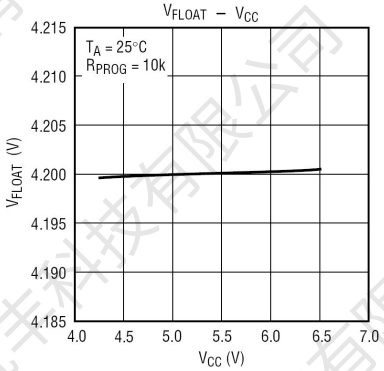



$V_{FLOAT}$ – $I_{BAT}$

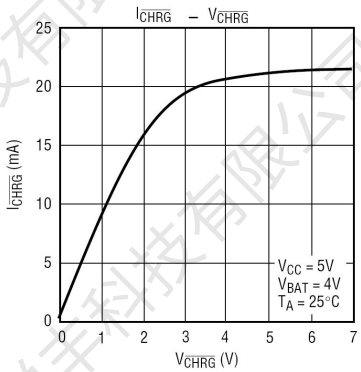


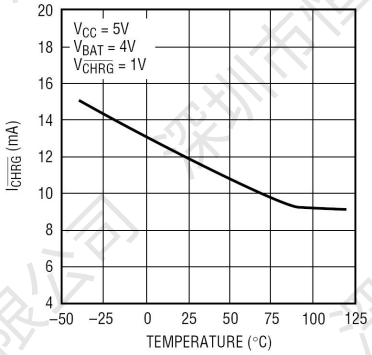




$V_{FLOAT}$ – $V_{CC}$

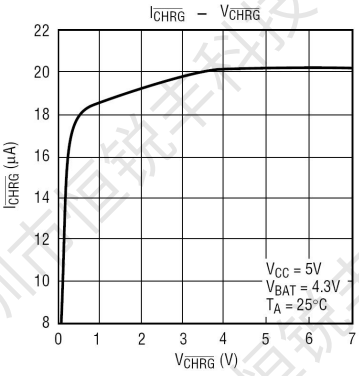



$I_{\overline{CHRG}}$ – $V_{\overline{CHRG}}$

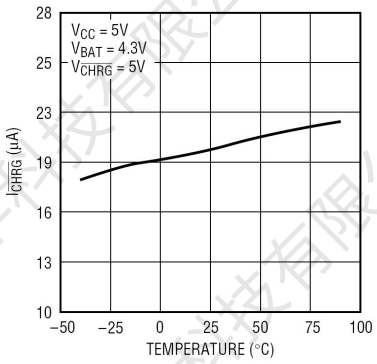


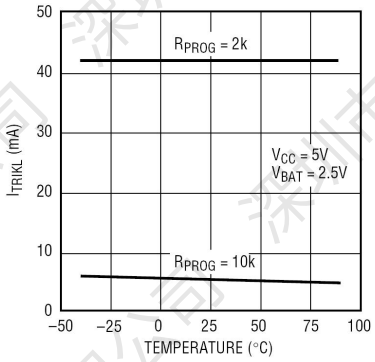



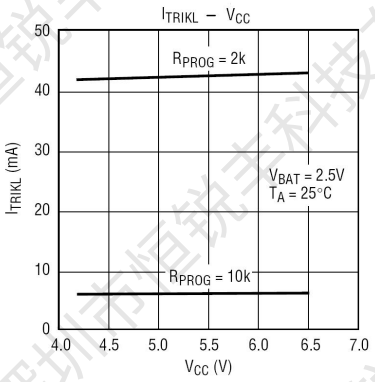

$I_{\overline{CHRG}}$ – $V_{\overline{CHRG}}$

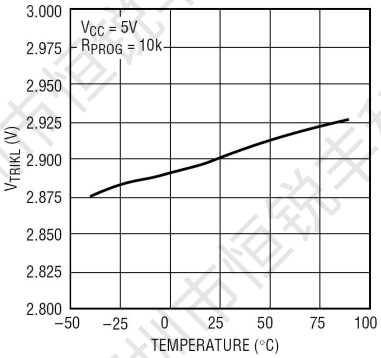


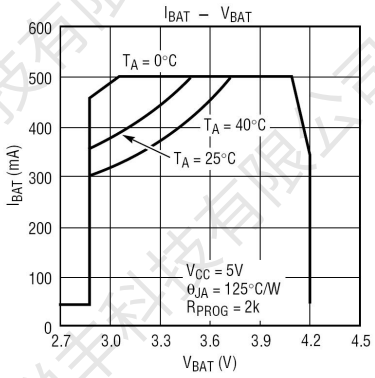
## 电参数曲线图 / Electrical Characteristic Curve

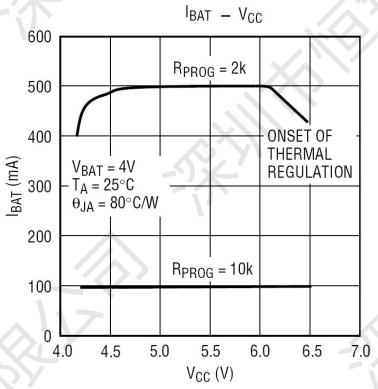


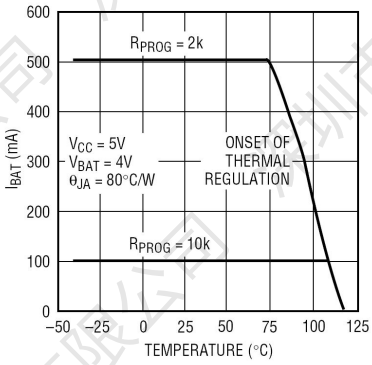



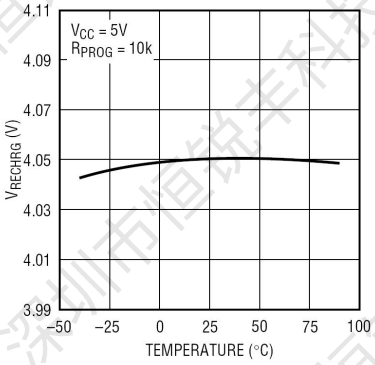



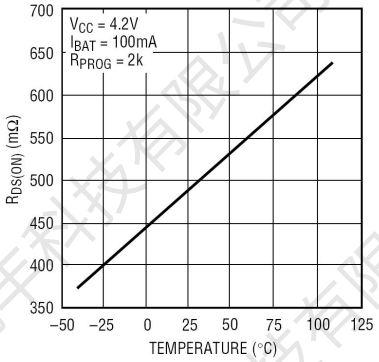



## 工作原理 / OPERATIOU

BRCL4054ME是一款采用恒定电流/恒定电压算法的单节锂离子电池充电器。它能够提供800mA的充电电流（借助一个热设计良好的PCB布局）和一个内部P沟道功率MOSFET和热调节电路。无需隔离二极管或外部电流检测电阻器；因此，基本充电器电路仅需要两个外部元件。不仅如此，BRCL4054ME还能够从一个USB电源获得工作电源。

The BRCL4054ME is a single cell lithium-ion battery charger using a constant-current/ constant – voltage algorithm. It can deliver up to 800mA of charge current (using a good thermal PCB layout) with a final float voltage accuracy of ±1%. The BRCL4054ME includes an internal P-channel power MOSFET and thermal regulation circuitry. No blocking diode or external current sense resistor is required; thus, the basic charger circuit requires only two external components. Furthermore, the BRCL4054ME is capable of operating from a USB power source.

## 正常充电循环 / Normal Charge Cycle

当$V_{cc}$引脚电压升至UVLO门限电平以上且在PROG引脚与地之间连接了一个精度为1%的设定电阻器或当一个电池与充电器输出端相连时，一个充电循环开始。如果BAT引脚电平低于2.9V，则充电器进入涓流充电模式。在该模式中，BRCL4054ME提供约1/10 的设定充电电流，以便将电流电压提升至一个安全的电平，从而实现满电流充电。

A charge cycle begins when the voltage at the $V_{CC}$ pin rises above the UVLO threshold level and a 1% program resistor is connected from the PROG pin to ground or when a battery is connected to the charger output. If the BAT pin is less than 2.9V, the charger enters trickle charge mode. In this mode, the BRCL4054ME supplies approximately 1/10 the programmed charge current to bring the battery voltage up to a safe level for full current charging.

当BAT引脚电压升至2.9V以上时 ,充电器进入恒定电流模式 ,此时向电池提供恒定的充电电流。当BAT引脚电压达到最终浮充电压（4.2V）时，BRCL4054ME进入恒定电压模式，且充电电流开始减小。当充电电流降至设定值的1/10，充电循环结束。

When the BAT pin voltage rises above 2.9V, the charger enters constant-current mode, where the programmed charge current is supplied to the battery. When the BAT pin approaches the final float voltage (4.2V), the BRCL4054ME enters constant-voltage mode and the charge current begins to decrease. When the charge current drops to 1/10 of the programmed value, the charge cycle ends.

## 充电电流的设定 / Programming Charge Current

充电电流是采用一个连接在PROG引脚与地之间的电阻器来设定的。电流充电电流是PROG引脚输出电流的1000倍。设定电阻器和充电电流采用下列公式来计算：

The charge current is programmed using a single resistor from the PROG pin to ground. The battery charge current is 1000 times the current out of the PROG pin. The program resistor and the charge current are calculated using the following equations:

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

从BAT引脚输出的充电电流可通过监视PROG引脚电压随时确定，公式如下：

The charge current out of the BAT pin can be determined at any time by monitoring the PROG pin voltage using the following equation:

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

## 充电终止 / Charge Termination

当充电电流在达到最终浮充电压之后降至设定值的1/10时，充电循环被终止。该条件是通过采用一个内部滤波比较器对PROG引脚进行监控来检测的。当PROG引脚电压降至100mV以下的时间超过$t_{TERM}$(一般为1.0ms)时，充电被终止。充电电流被锁断，BRCL4054ME进入待机模式，此时输入电源电流降至200μA。（注：C/10终止在涓流充电和热限制模式中失效）。

A charge cycle is terminated when the charge current falls to 1/10th the programmed value after the final float voltage is reached. This condition is detected by using an internal, filtered comparator to monitor the PROG pin. When the PROG pin voltage falls below 100mV[1] for longer than $t_{TERM}$ typically 1ms), charging is terminated. The charge current is latched off and the BRCL4054ME enters standby mode, where the input supply current drops to 200μA. (Note: C/10 termination is disabled in trickle charging and thermal limiting modes).

充电时，BAT引脚上的瞬变负载会使PROG引脚电压在DC充电电流降至设定值的1/10之间短暂地降至100mV以下。终止比较器上的1.0ms滤波时间（$t_{TERM}$）确保这种性质的瞬变负载不会导致充电循环过早终止。一旦平均充电电流降至设定值的1/10以下，BRCL4054ME即终止充电循环并停止通过BAT引脚提供任何电流。在这种状态下，BAT引脚上的所有负载都必须由电池来供电。

When charging, transient loads on the BAT pin can cause the PROG pin to fall below 100mV for short periods of time before the DC charge current has dropped to 1/10th the programmed value. The 1ms filter time ($t_{TERM}$) on the termination comparator ensures that transient loads of this nature do not result in premature charge cycle termination. Once the average charge current drops below 1/10th the programmed value, the BRCL4054ME terminates the charge cycle and ceases to provide any current through the BAT pin. In this state, all loads on the BAT pin must be supplied by the battery.

在待机模式中，BRCL4054ME对BAT引脚电压进行连续监控。如果该引脚电压降到4.05V的再充电电门限($V_{RECHRG}$)以下，则另一个充电循环开始并再次向电池供应电流。当在待机模式中进行充电循环的手动再启动时，必须取消然后再施加输入电压，或者必须关断充电器并使用PROG引脚进行再启动。图1示出了一个典型充电循环的状态图。

The BRCL4054ME constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the 4.05V recharge threshold ($V_{RECHRG}$), another charge cycle begins and current is once again supplied to the battery. To manually restart a charge cycle when in standby mode, the input voltage must be removed and reapplied, or the charger must be shut down and restarted using the PROG pin. Figure 1 shows the state diagram of a typical charge cycle.

## 充电状态指示器 / Charge Status Indicator ($\overline{CHRG}$)

充电状态输出具有三种不同的状态：强下拉（约10mA）、弱下拉（约20μA）和高阻抗。强下拉状态表示BRCL4054ME处于一个充电循环中。一旦充电循环被终止，则引脚状态由欠压闭锁条件来决定。弱下拉状态表示$V_{CC}$ 满足UVLO条件且BRCL4054ME处于充电就绪状态。高阻抗状态表示BRCL4054ME处于欠压闭锁模式：要么$V_{CC}$ 高出BAT引脚电压的幅度不足100mV，要么施加在$V_{CC}$引脚上的电压不足。可采用一个微处理器来区分这三种状态--在“应用信息”部分将对此方法进行讨论。

The charge status output has three different states: strong pull-down (~10mA),weak pull-down (~20μA) and high impedance. The strong pull-down state indicates that the BRCL4054ME is in a charge cycle. Once the charge cycle has terminated, the pin state is determined by under voltage lockout conditions. A weak pull-down indicates that $V_{CC}$ meets the UVLO conditions and the BRCL4054ME is ready to charge. High impedance indicates that the BRCL4054ME is in under voltage lockout mode: either $V_{CC}$ is less than 100mV above the BAT pin voltage or insufficient voltage is applied to the $V_{CC}$ pin. A microprocessor can be used to distinguish between these three states—this method is discussed in the Applications Information section.

## 热限制 / Thermal Limiting

如果芯片温度试图上升超过120℃的预设值以上，则一个内部热反馈环路将减小设定的充电电流。该功能可防止BRCL4054ME过热，并允许用户提高给定电路板功率处理能力的上限而没有损坏BRCL4054ME的风险。在保证充电器将在最坏情况条件下自动减小电流的前提下，可根据典型（而不是最坏情况）环境温度来设定充电电流。有关Thin SOT功率方面的考虑将在“应用信息”部分做进一步讨论。

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 120℃. This feature protects the RCL4054ME from excessive temperature and allows the user to push the limits of the power handling capability of a given circuit board without risk of damaging the BRCL4054ME. The charge current can be set according to typical (not worst-case) ambient temperature with the assurance that the charger will automatically reduce the current in worst-case conditions. ThinSOT power considerations are discussed further in the Applications Information section.

## 欠压闭锁 / Under voltage Lockout (UVLO)

一个内部欠压闭锁电路对输入电压进行监控，并在$V_{cc}$升至欠压闭锁门限以上之前使充电器保持在停机模式。UVLO电路有一个内置的滞后200Mv.此外在功率MOSFET的反向电流保护，UVLO电路将使充电器保持在停机模式。如果UVLO比较器发生跳变，则在Vcc升至比电池电压高100mV之前充电器将不会退出停机模式。

An internal under voltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until $V_{CC}$ rises above the under voltage lockout threshold. The UVLO circuit has a built-in hysteresis of 200mV. Furthermore, to protect against reverse current in the power MOSFET, the UVLO circuit keeps the charger in shutdown mode if $V_{CC}$ falls to within 30mV of the battery voltage. If the UVLO comparator is tripped, the charger will not come out of shutdown mode until $V_{CC}$ rises 100mV above the battery voltage.

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