采用 ThinSOT 封装的独立线性锂离子电池充电器 ME4054-4.2V

描述：

ME4054 是一款完整的单节锂离子电池用恒定电流/恒定电压线性充电器。其中 ThinSOT 封装与较少的外部元器件数目使得 ME4054 成为便携式应用的理想选择。而且 ME4054 是专为在 USB 电源规范内工作而设计的。

由于采用内部 MOSFET 构架，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。充电电压固定为 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的 1/10 时，ME4054 将自动终止充电循环。

当输入电压（交流适配器或 USB 电源）被拿掉时，ME4054 自动进入一个低电流状态，将电池漏电流降至 2uA 以下，可将 ME4054 置于停机模式，从而将供电电流降至 25uA。

ME4054 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。

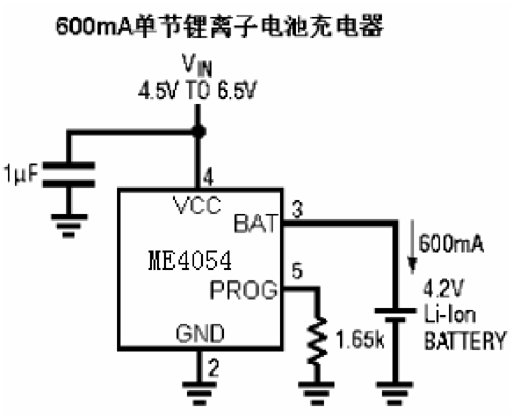
特点：

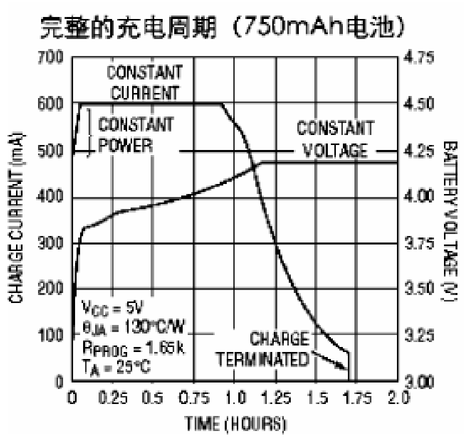
- 高达 800mA 的可编程充电电流
- 无需 MOSFET、检测电阻器和隔离二极管
- 用于单节锂离子电池、采用 ThinSOT 封装的完整线性充电器
- 恒定电流/恒定电压操作，并具有可在无过热危险的情况下实现充电速率最大化的热调节功能
- 直接从 USB 端口给锂离子电池充电
- 精度达 1%的 4.2V 预设充电电压
- 用于电池电量检测的充电电流监控器输出
- 自动再充电
- 充电状态输出引脚
- C/10 充电终止
- 停机模式下供电电流为 25uA
- 2.9V 涓流充电门限（ME4054）
- 可提供涓流充电器件版本（ME4054X）

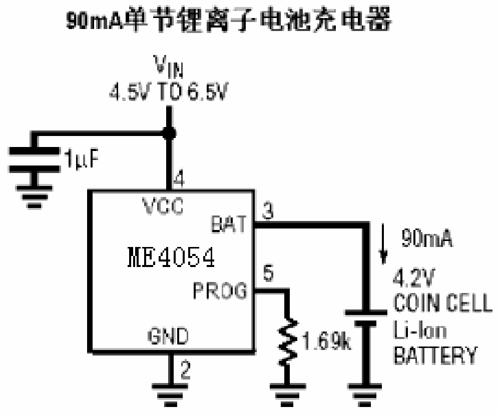
应用：

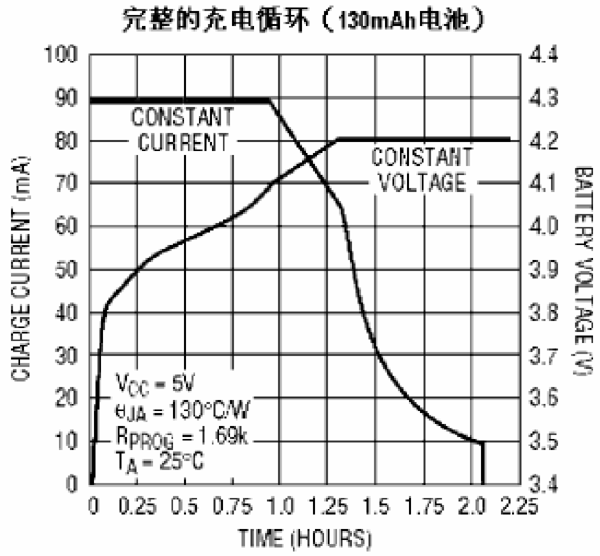
- 蜂窝电话、PDA、MP3 播放机
- 充电座
- 蓝牙应用

典型应用：

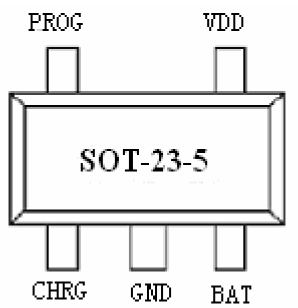








引脚排列图：



引脚定义：

引脚号 SOT-23-5	符号	引脚描述
1	CHRG	漏极开路充电输出，充电状态指示
2	GND	地
3	BAT	充电电流输出
4	VCC	电源输入
5	PROG	充电电流设定

引脚功能：

$\overline{CHRG}$ (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 $\overline{CHRG}$ 引脚拉至低电平。当充电循环结束时，一个约 20μA 的弱下拉电流源被连接至 $\overline{CHRG}$ 引脚，指示一个"AC 存在"状态。当 ME4054 检测到一个欠压闭锁条件时，$\overline{CHRG}$ 引脚被强制为高阻抗状态。

GND (引脚 2)：地。

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。

V_{CC} (引脚 4)：正输入电源电压。该引脚向充电器供电。V_{CC} 的变化范围在 4.25V 至 6.5V 之间，并应通过至少一个 1μF 电容器进行旁路。当 V_{CC} 降至 BAT 引脚电压的 30mV 以内时，ME4054 进入停机模式，从而使 I_{BAT} 降至 2μA 以下。

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 R_{PROG} 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，公式如下：

$$I_{BAT} = (V_{PROG}/R_{PROG}) \bullet 1000$$

PROG 引脚还可用来关断充电器。将设定电阻器与地断接，内部一个 3μA 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 25μA。该引脚还被箝位在 2.4V 左右。把该引脚驱动至箝位电压以上将吸收高达 1.5mA 的电流。重新将 R_{PROG} 与地相连将使充电器恢复正常操作状态。

最大绝对额定值：

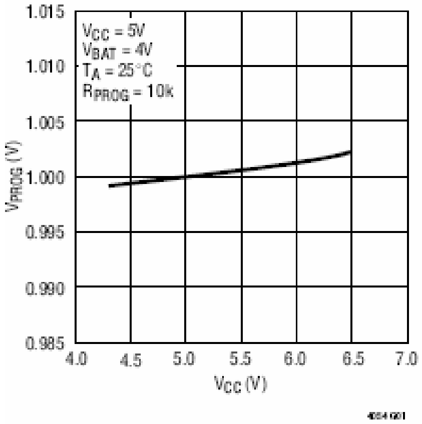
参数	额定值
输入电源电压	－0.3V～10V
PROG	-0.3V～Vcc＋0.3V
BAT	-0.3V～7V
CHRG	-0.3V～10V
BAT 短路持续时间	连续
BAT 引脚电流	800mA
PROG 引脚电流	800uA
最大结温	125℃
工作环境工作温度	-40℃～85℃
贮存温度环境	-65℃～125℃
引脚温度（焊接时间 10 秒）	260℃

电特性： 凡标注●表示该指标适合整个工作温度范围，否则仅指 T_A =25℃，Vcc=5V，除非特别注明。

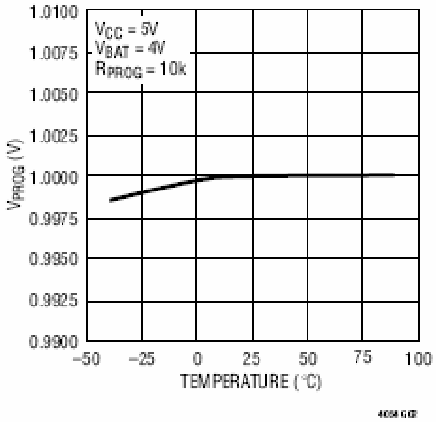
符号	参数	条件		最小值	典型值	最大值	单位
Vcc	输入电源电压		●	4.25		6.5	V
Icc	输入电源电流	充电模式，R_{PROG}=10K	●		300	2000	uA
		待机模式（充电终止）	●		200	500	uA
		停机模式（R_{PROG} 未连接，Vcc 小于 V_{BAT}）	●		25	50	uA
V_{FLOAT}	稳定输出电压	0℃≤T_A≤85℃， I_{BAT}=40mA		4.158	4.2	4.242	V
I_{BAT}	BAT 引脚电流	R_{PROG}=10K，电流模式	●	93	100	107	mA
		R_{PROG}=2K，电流模式	●	465	500	535	mA
		待机模式，V_{BAT}=4.2V	●	0	-2.5	-6	uA
		停机模式（R_{PROG} 未连接）			±1	±2	uA
		睡眠模式，Vcc＝0V			±1	±2	uA
I_{TRILK}	涓流充电电流	V_{BAT}＜V_{TRILK}，R_{PROG}＝2K	●	20	45	70	mA
V_{TRILK}	涓流充电门限电压	R_{PROG}＝10K，V_{BAT} 上升		2.8	2.9	3.0	V
V_{TRHYS}	涓流充电迟滞电压	R_{PROG}＝10K		60	80	110	mV
V_{UV}	Vcc 欠压闭锁门限	从 Vcc 低至高	●	3.7	3.8	3.92	V
V_{UVHYS}	Vcc 欠压闭锁迟滞		●	150	200	300	mV
V_{MSD}	手动停机门限电压	PROG 引脚电平上升	●	1.15	1.21	1.30	V
		PROG 引脚电平下降	●	0.9	1.0	1.1	V
V_{ADS}	Vcc- V_{BAT} 闭锁门限	Vcc 从低到高		70	100	140	mV
		Vcc 从高到低		5	30	50	mV
I_{TERM}	C/10 终止电流门限	R_{PROG}＝10K	●	0.085	0.10	0.115	mA /mA
		R_{PROG}＝2K	●	0.085	0.10	0.115	mA /mA
V_{PROG}	PROG 引脚电压	R_{PROG}＝10K，电流模式	●	0.93	1.0	1.07	V
I_{CHRG}	CHRG 弱下拉电流	V_{CHRG}＝5V		8	20	35	uA
V_{CHRG}	CHRG 输出低电压	I_{CHRG}＝5mA			0.35	0.6	V
V_{RECHRG}	再充电电池门限	V_{FLOAT}－V_{RECHRG}		100	150	200	mV
T_{LIM}	恒温度模式结温				120		℃
R_{ON}	功率 FET“导通”电阻（在 Vcc 与 BAT 之间）				600		mΩ
T_{SS}	软启动时间	I_{BAT}＝0 至 I_{BAT}＝1000V/ R_{PROG}			100		uS
T_{RE}	再充滤波时间	V_{BAT} 高至低		0.75	2	4.5	mS
T_{TERM}	终止滤波时间	I_{BAT} 降至 I_{CHG}/10 以下		400	1000	2500	uS
I_{PROG}	PROG 上拉电流				3		uA

典型性能特性图：

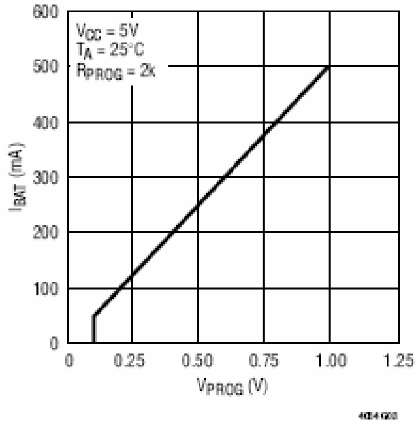
恒定电流模式下 PROG 引脚电压与电源电压的关系曲线



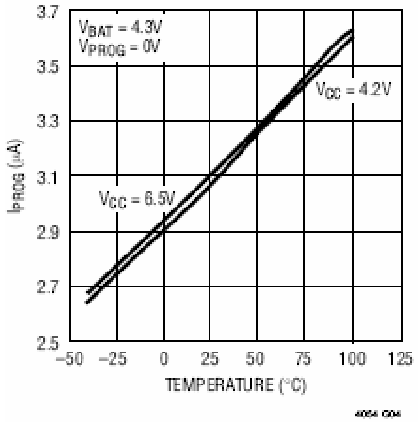
PROG 引脚电压与温度的关系曲线



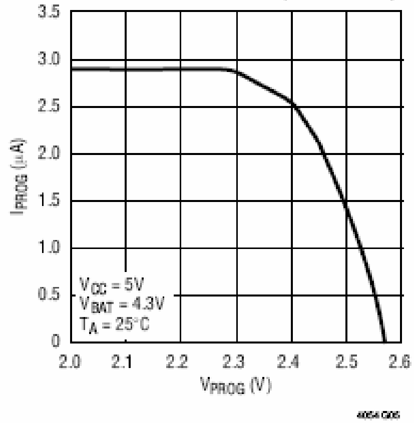
充电电流与 PROG 引脚电压的关系曲线



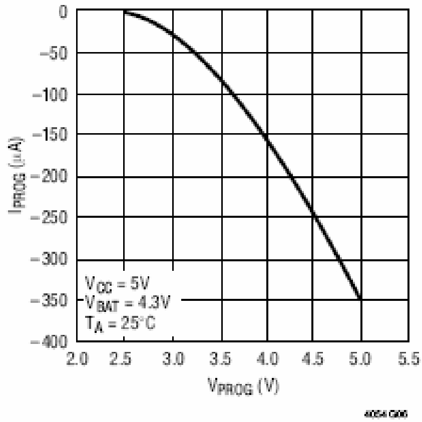
PROG 引脚上拉电流与温度和电源电压的关系曲线



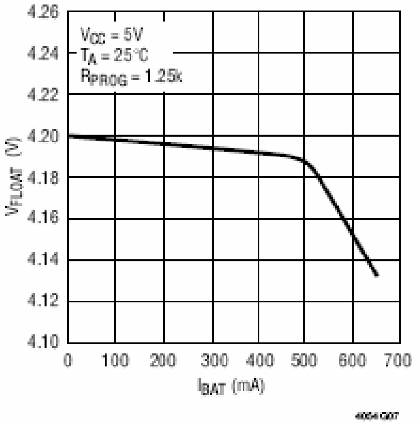
PROG 引脚电流与 PROG 引脚电压的关系曲线(上拉电流)



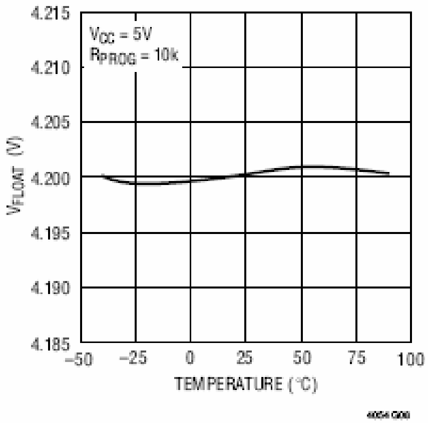
PROG 引脚电流与 PROG 引脚电压的关系曲线(箝位电流)



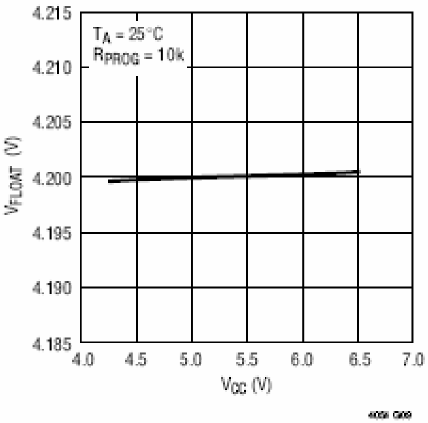
稳定输出 (浮充) 电压与充电电流的关系曲线



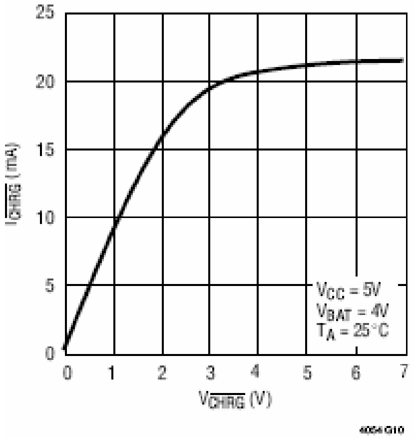
稳定输出 (浮充) 电压与温度的关系曲线



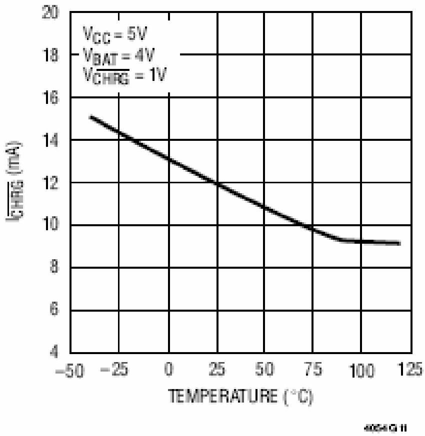
稳定输出 (浮充) 电压与电源电压的关系曲线



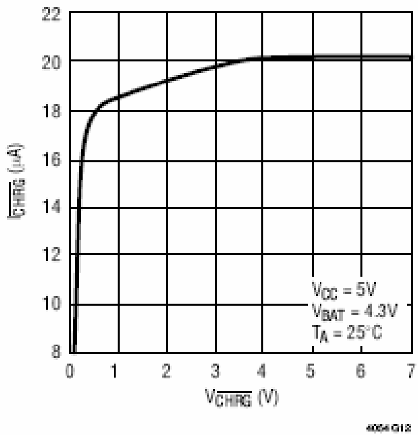
强下拉状态下的 $\overline{CHRG}$ 引脚 I-V 曲线



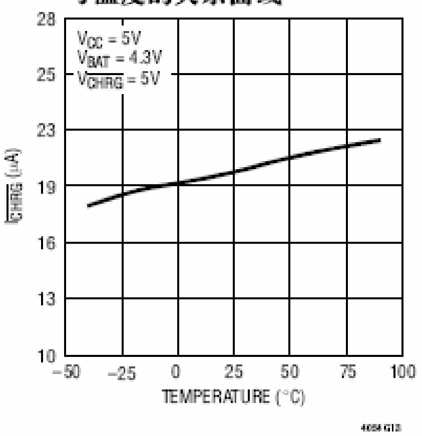
强下拉状态下 $\overline{CHRG}$ 引脚电流与温度的关系曲线



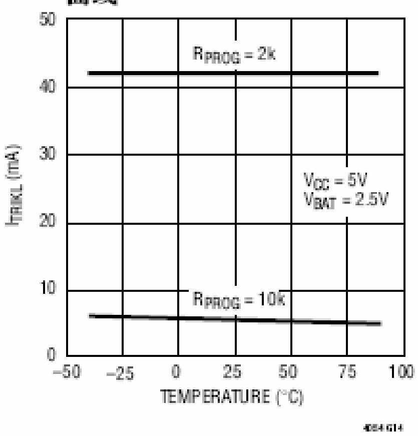
弱下拉状态的 $\overline{CHRG}$ 引脚 I-V 曲线



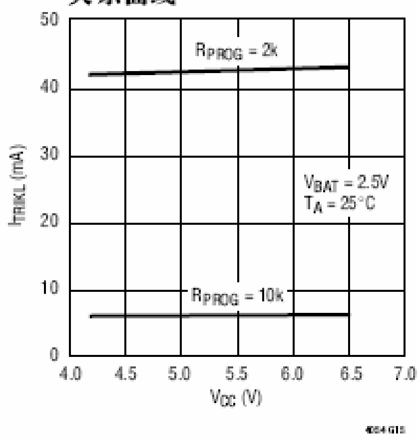
弱下拉状态 $\overline{CHRG}$ 引脚电流与温度的关系曲线



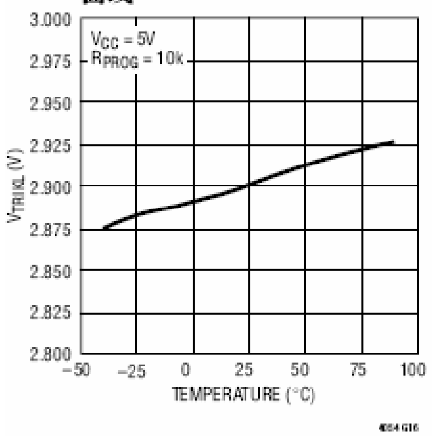
涓流充电电流与温度的关系曲线



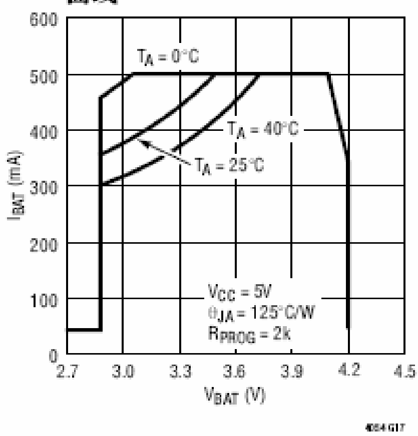
涓流充电电流与电源电压的关系曲线



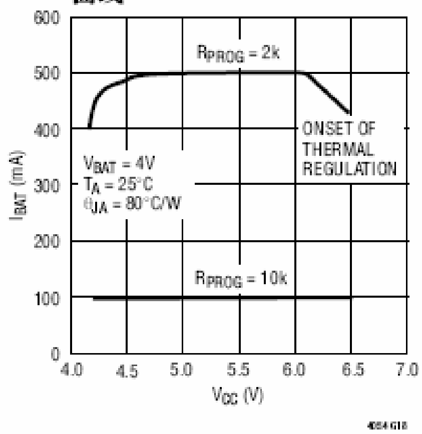
涓流充电门限与温度的关系曲线



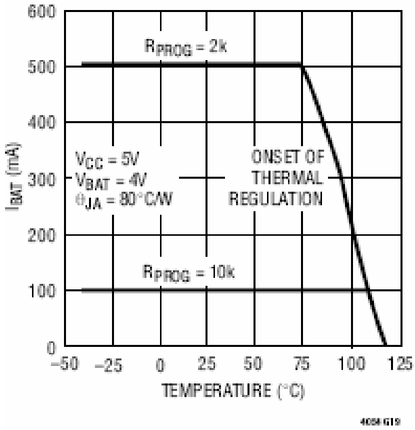
充电电流与电池电压的关系曲线



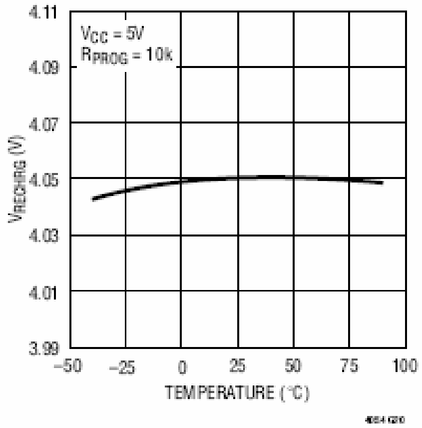
充电电流与电源电压的关系曲线



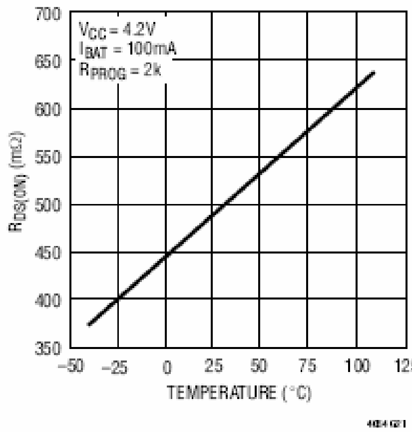
充电电流与环境温度的关系曲线



再充电电压门限与温度的关系曲线



功率 FET "导通" 电阻与温度的关系曲线



工作原理：

ME4054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 ±1% 的最终浮充电压精度。ME4054包括一个内部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，ME4054还能够从一个 USB 电源获得工作电源。

正常充电循环

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 ME4054 提供约1/10 的设定充电电流，以便将电池电压提升至一个安全的电平，从而实现满电流充电。(注 ME4054X 不包括该涓流充电功能)。

当 BAT 引脚电压升至 2.9V 以上时，充电器进入恒定电流模式，此时向电流提供设定的充电电流。当 BAT 引脚电压达到最终浮充电压 (4.2V) 时，ME4054 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 时，充电循环结束。

充电电流的设定

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。电池充电电流是 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：

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

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：

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

充电终止

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[1] 以下的时间超过 t_{TERM} (一般为 1ms) 时，充电被终止。充电电流被锁断，ME4054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)。

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 之前短暂地降至100mV 以下。终止比较器上的 1ms 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，ME4054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。

在待机模式中，ME4054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起动时，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 引脚进行再起动。图 1 示出了一个典型充电循环的状态图。

充电状态指示器 ($\overline{CHRG}$)

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 ME4054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 ME4054处于充电就绪状态。高阻抗状态表示 ME4054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。

热限制

如果片温度试图升至约 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 ME4054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 ME4054 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 ThinSOT 功率方面的考虑将在“应用信息”部分做进一步讨论。

欠压闭锁

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 电路具有一个内置 200mV 迟滞。另外，为防止功率 MOSFET 中的电流反向流动，当 V_{CC} 降到比电池电压高出的幅度不足 30mV 时，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 V_{CC} 升至比电池电压高 100mV 之前充电器将不会退出停机模式。

手动停机

在充电循环中的任何时刻都能通过去掉 R_{PROG} (从而使 PROG 引脚浮置) 来把 ME4054置于停机模式。这使得电池漏电流降至 2μA 以下，且电源电流降至 50μA 以下。重新连接设定电阻器可启动一个新的充电循环。

在手动停机模式中，只要 V_{CC} 高到足以超过 UVLO 条件，$\overline{\text{CHRG}}$ 引脚都将处于弱下拉状态。如果 ME4054 处于欠压闭锁模式，则 $\overline{\text{CHRG}}$ 引脚呈高阻抗状态：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。

自动再起动

一旦充电循环被终止 ME4054 立即采用一个具有 2ms 滤波时间 ($t_{RECHARGE}$) 的比较器来对 BAT 引脚上的电压进行连续监控。当电池电压降至 4.05V (大致对应于电池容量的 80% 至 90%) 以下时，充电循环重新开始。这确保了电池被维持在 (或接近) 一个满充电状态，并免除了进行周期性充电循环启动的需要。在再充电循环过程中，$\overline{\text{CHRG}}$ 引脚输出进入一个强下拉状态。

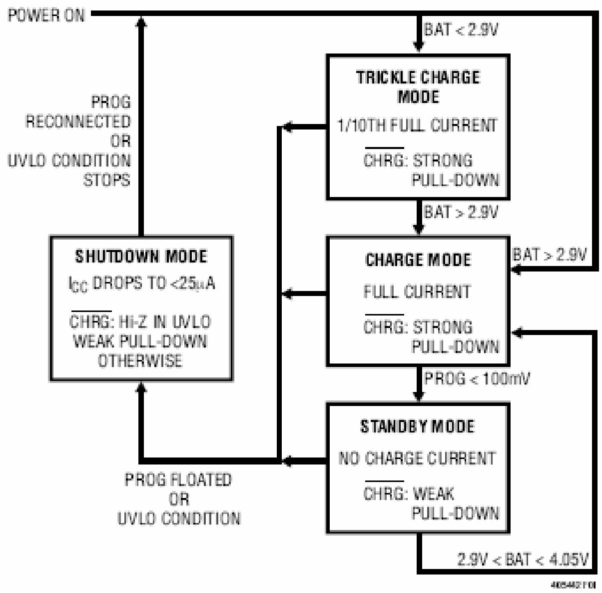
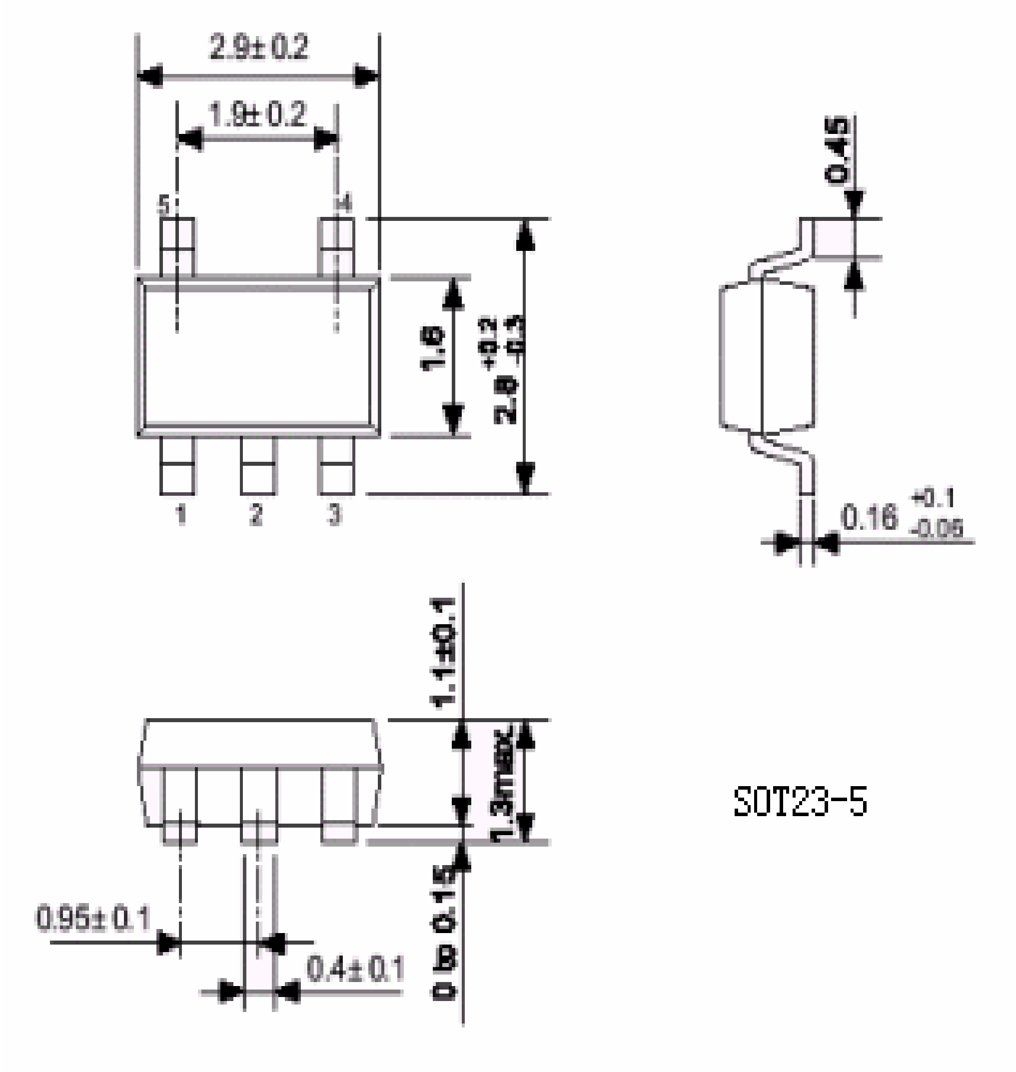


图 1：一个典型充电循环的状态图

封装尺寸：


2.9±0.2
1.9±0.2
5
4
1
2
3
1.6
2.8 +0.2 -0.3
0.45
0.16 +0.1 -0.06
1.1±0.1
1.3max
0 to 0.15
0.95±0.1
0.4±0.1
SOT23-5

800mA Lithium Ion Battery Linear Charger ME4064A

General Description

ME4064A is a complete constant-current/constant voltage linear charger for single cell lithium-ion batteries. Furthermore the ME4064A is specifically designed to work within USB power specifications.

No external sense resistor is needed and no blocking diode is required due to the internal PMOSFET 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 ME4064A automatically terminates the charge cycle when the charge current drops to 1/10th the programmed value after the final float voltage is reached.

When the input supply (wall adapter or USB supply) is removed the ME4064A automatically enters a low current state dropping the battery drain current to less than 2μA.The ME4064A can be put into shutdown mode reducing the supply current to 55μA.

Other features include charge current monitor, undervoltage lockout, automatic recharge and a status.

Features

- ●Protection of battery cell reverse connection
- ●No MOSFET sense resistor or blocking diode required
- ●Complete Linear Charger in ThinSOT Package for Single Cell Lithium-Ion Batteries
- ●Constant-Current/Constant-Voltage operation with thermal regulation to maximize Rate Without risk of overheating.
- ● Preset 4.2V charge voltage with ±1% accuracy
- ● Automatic Recharge
- ●Charges Single Cell Li-Ion Batteries Directly from USB Port
- ●C/10 charge termination
- ● 55μA supply current in shutdown
- ● 2.9V trickle current charge threshold
- ● Soft-Start limits inrush current
- ●Charge Status Output Pin
- ●Available in SOT23-5 Package

Applications

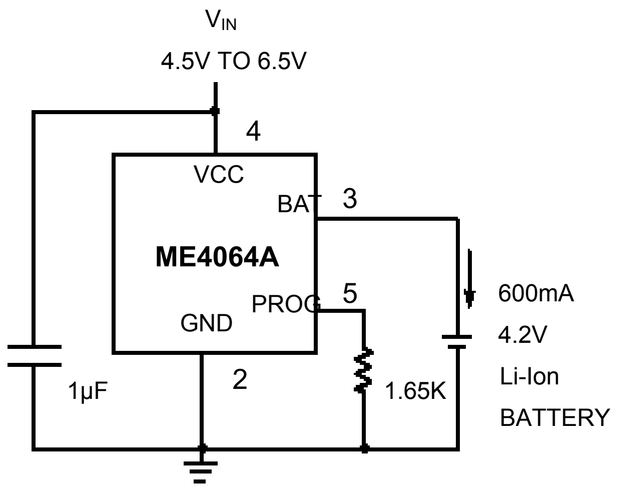
- ●Cellular Telephones, PDAs, MP3 Players
- ●Charging Docks and Cradles
- ●Bluetooth Applications

Selection Guide

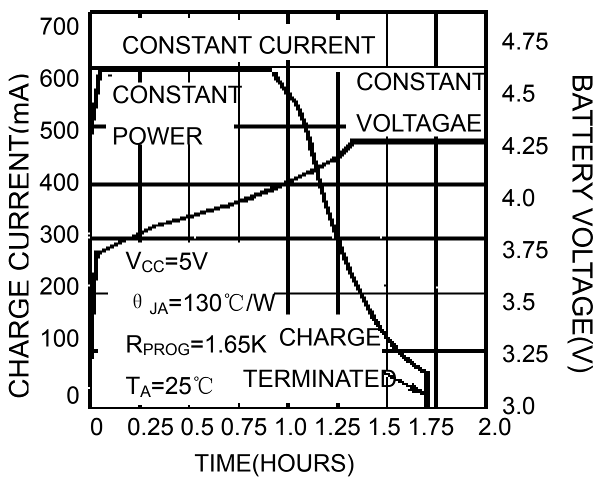
ME 40 64 X X X

- X — Environment mark
- X — Package: e.g.: M5: SOT23-5
- X — Function e.g.: A: The Thermal protection temperature is 110℃ and C/10 charge termination
- 64 — Product Type
- 40 — Product Series
- ME — Microne

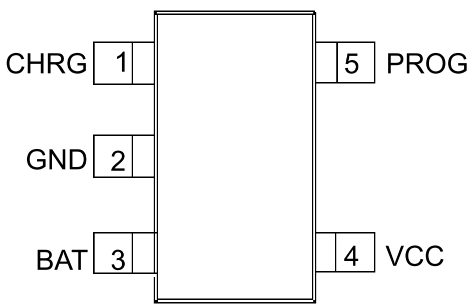
600mA Single Cell Li-Ion Charger



Typical charge cycle（750mAh batter



Pin Configuration



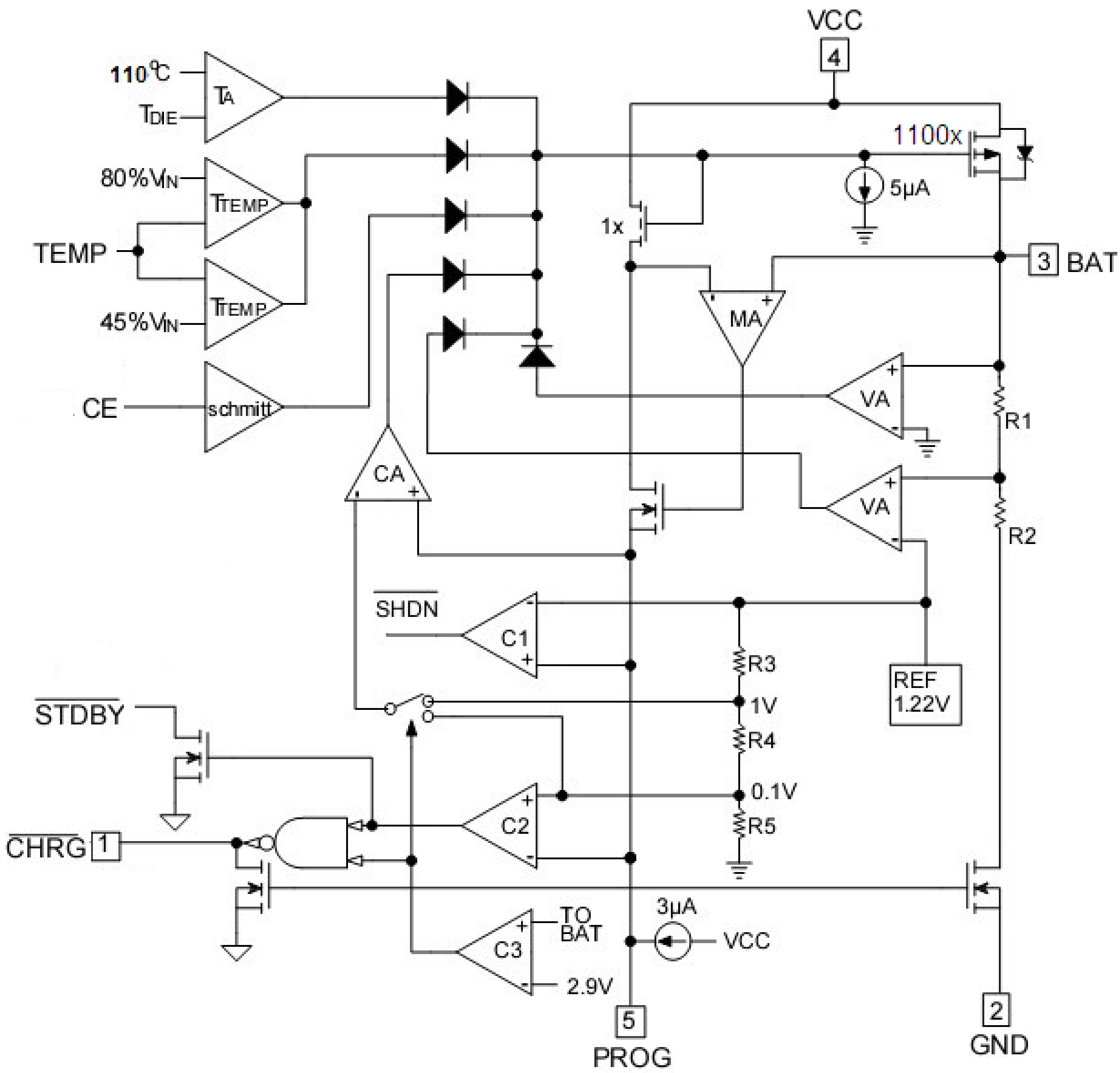
Package type： SOT23-5

Pin Assignment

ME4064AM5G

Pin Num.	Symbol	Function
1	CHRG	**Open-Drain charge status output** When the battery is being charged, the $\overline{CHRG}$ pin is pulled low by an internal switch, otherwise, $\overline{CHRG}$ pin is in high impedance state.
2	GND	**Ground**
3	BAT	**Battery connection Pin** Connect the positive terminal of the battery to this pin. Dropping BAT pin's current to less than 2μA when IC in disable mode or in sleep mode. BAT pin provides charge current to the battery and provides regulation voltage of 4.2V.
4	VCC	**Positive input supply voltage** Provides power to the internal circuit. When V_{CC} drops to within 80mV of the BAT pin voltage, the ME4064A enters low power sleep mode, dropping I_{BAT} to less than 2μA.
5	PROG	**Constant Charge Current Setting and Charge Current Monitor Pin** The charge current is programmed by connecting a resistor R_{PROG} from this pin to GND. When in precharge mode, the PROG pin's voltage is regulated to 0.1V. When charging in constant-current mode this pin's voltage is regulated to 1V. In all modes during charging, the voltage on this pin can be used to measure the charge current using the following formula: $I_{BAT} = \frac{V_{PROG}}{R_{PROG}} * 1100$

Block Diagram



Absolute Maximum Ratings

Parameter	Rating	Unit
Input supply voltage : V_{CC}	-0.3～6.5	V
PROG pin voltage	-0.3～VCC+0.3	V
BAT pin voltage	-0.3～6.5	V
$\overline{CHRG}$ pin voltage	-0.3～6.5	V
BAT pin current	800	mA
PROG pin current	1200	μA
Maximum junction temperature	145	℃
Operating ambient temperature :T_{opa}	-40～85	℃
Storage temperature :T_{str}	-65～125	℃
Soldering temperature and time	+260（Recommended 10S）	℃

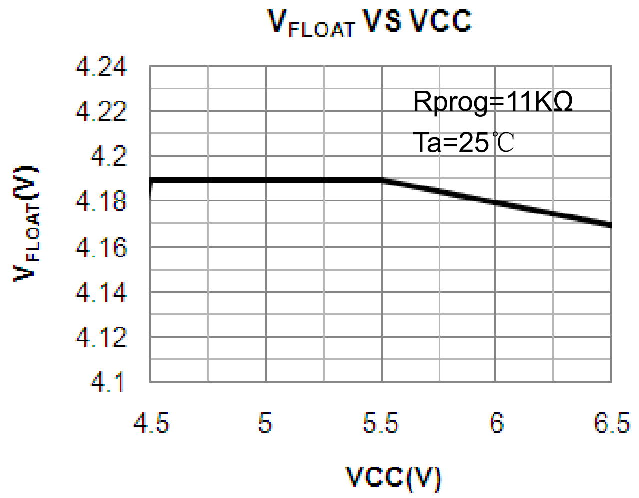
Caution: The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.

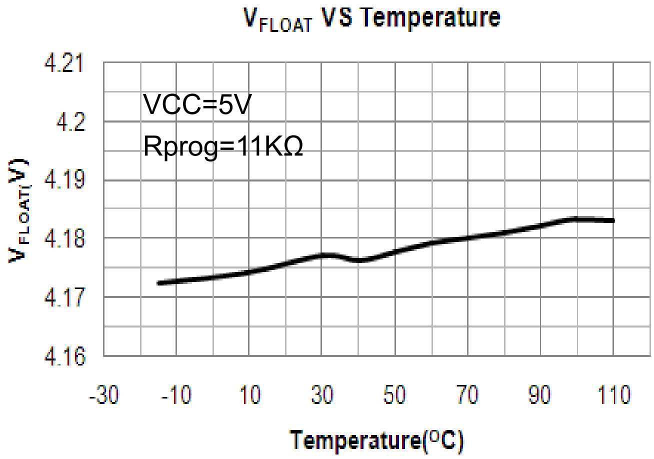
Electrical Characteristics

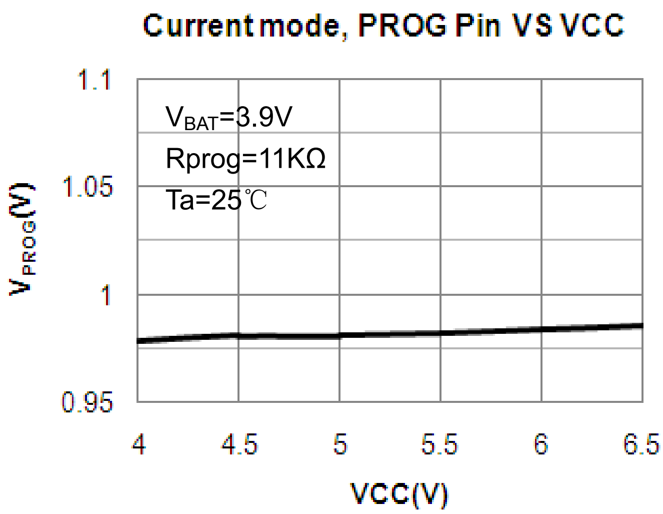
Symbol	Parameter	Condition	Min	Typ.	Max	Unit
V_{CC}	Input supply voltage	●	4.0	5.0	6.5	V
I_{CC} -I_{BAT}	static current	●Charge mode, R_{PROG}=1.1KΩ	-	150	500	μA
		●Standby mode(charge end)	-	55	100	μA
		●Shutdown mode（R_{PROG} not connected, V_{CC}<V_{BAT}, or V_{CC}<V_{UV}）	-	55	100	μA
V_{FLOAL}	Regulated output voltage	0℃≤T_A≤85℃	4.158	4.2	4.242	V
I_{BAT}	BAT pin current (The condition of current mode is V_{BAT}=3.9V)	●R_{PROG}=2.2KΩ, current mode	450	500	550	mA
		●R_{PROG}=1.1KΩ,current mode	950	1000	1050	mA
		●Standby mode: V_{BAT}=4.2V	0	-2.5	-6	μA
		Shutdown mode, R_{PROG} not connected	-	±1	±2	μA
		Sleep mode, V_{CC}=0V	-	-1	-2	μA
I_{TRIKL}	Trickle charge current	●V_{BAT}<V_{TRIKL}, R_{PROG}=1.1KΩ	120	130	140	mA
V_{TRIKL}	Trickle charge threshold voltage	R_{PROG}=1.1KΩ, V_{BAT} rising	2.8	2.9	3.0	V
V_{TRHYS}	Trickle voltage hysteresis voltage	R_{PROG}=1.1KΩ	150	200	250	mV
V_{UV}	V_{CC} under voltage lockout threshold	● V_{CC} from low to high	3.5	3.7	3.9	V
V_{UVHYS}	V_{CC} under voltage lockout hysteresis	●	150	200	300	mV
V_{ASD}	V_{CC}-V_{BAT} lockout threshold voltage	V_{CC} from low to high	100	140	180	mV
		V_{CC} from high to low	50	80	110	
I_{TERM}	termination current threshold	●R_{PROG}=2.2KΩ	60	70	80	mA
		●R_{PROG}=1.1KΩ	120	130	140	
V_{PROG}	PROG pin voltage	●R_{PROG}=1.1KΩ, current mode	0.9	1.0	1.1	V
V_{CHRG}	$\overline{CHRG}$ Pin output low voltage	$I_{\overline{CHRG}}$ =5mA	-	0.3	0.6	V
ΔV_{RECHRG}	Recharge battery threshold voltage	V_{FLOAT} -V_{RECHRG}	120	180	240	mV
T_{LIM}	Thermal protection temperature		-	110	-	℃
R_{ON}	The resistance of power FET ”ON”（between V_{CC} and BAT）		-	650	-	mΩ
t_{SS}	Soft-start time	I_{BAT}=0 to I_{BAT}=1100V/R_{PROG}	-	20	-	μS
$t_{RECHARGE}$	Recharge comparator filter time	V_{BAT} from high to low	0.8	1.8	4	mS
t_{TERM}	Termination comparator filter time	I_{BAT} below I_{CHG}/10	0.8	1.8	4	mS
I_{PROG}	PROG pin pull-up current		-	2.0	-	μA

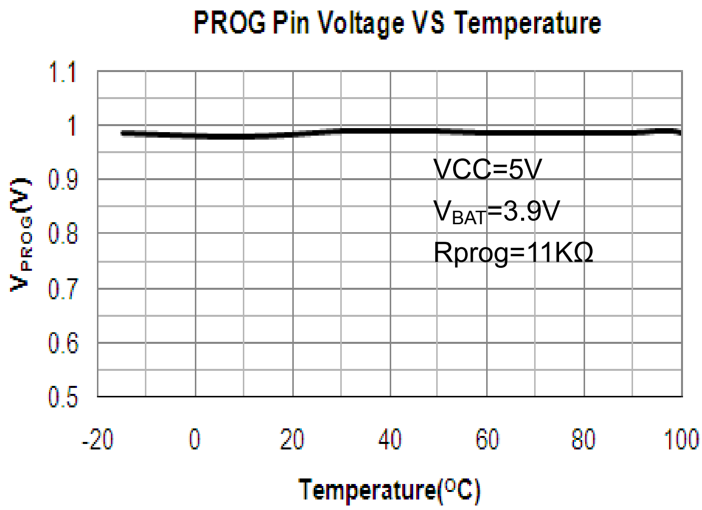
Note: The ● denotes specifications which apply over the full operating temperature rang, otherwise specifications are at T_A=25℃，V_{CC}=5V，unless otherwise specified.

Typical performance characteristics







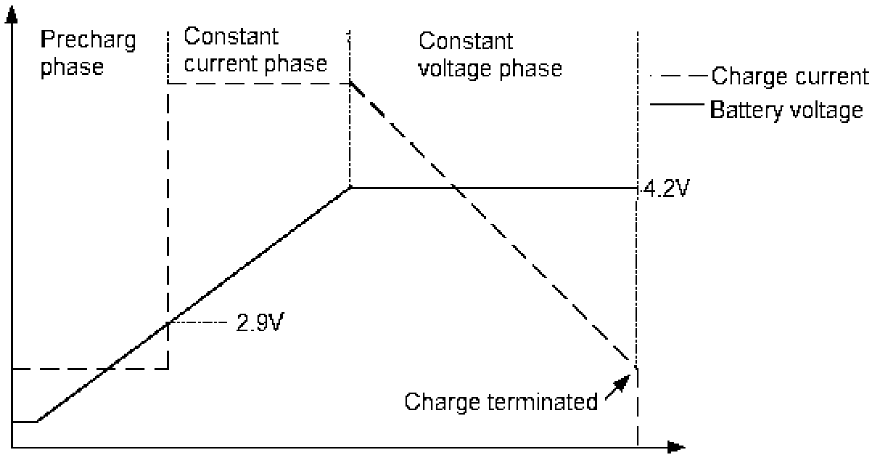


Description of the Principle

The ME4064A is a complete constant-current/constant-voltage linear charger for single cell lithium-ion batteries. Constant-current/constant-voltage to charger batter by internal MOSFET .It can deliver up to 800mA of charge current .No blocking diode or external current sense resistor is required. ME4064A include one Open-Drain charge status Pin: Charge status indicator $\overline{CHRG}$

The internal thermal regulation circuit reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 110℃. This feature protects the ME4064A 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 ME4064A or the external components. Another benefit of adopting thermal regulation is that charge current can be set according to typical, not worst-case, ambient temperatures for a given application with the assurance that the charger will automatically reduce the current in worst-case conditions.

The charge cycle begins when the voltage at the V_{CC} pin rises above the UVLO level, a current set resistor is connected from the PROG pin to ground. The $\overline{CHRG}$ pin outputs a logic low to indicate that the charge cycle is on going. At the beginning of the charge cycle, if the battery voltage is below 2.9V, the charge is in precharge mode to bring the cell voltage up to a safe level for charging. The charger goes into the fast charge constant-current mode once the voltage on the BAT pin rises above 2.9 V. In constant current mode, the charge current is set by R_{PROG}. When the battery approaches the regulation voltage 4.2V, the charge current begins to decrease as the ME4064A enters the constant-voltage mode. When the current drops to charge termination threshold, the charge cycle is terminated, and $\overline{CHRG}$ pin assumes a high impedance state to indicate that the charge cycle is terminated . The charge termination threshold is 10% of the current in constant current mode. To restart the charge cycle, remove the input voltage and reapply it . The charge cycle can also be automatically restarted if the BAT pin voltage falls below the recharge threshold. The on-chip reference voltage, error amplifier and the resistor divider provide regulation voltage with 1% accuracy which can meet the requirement of lithium-ion and lithium polymer batteries. When the input voltage is not present, or input voltage is below V_{BAT}, the charger goes into a sleep mode, dropping battery drain current to less than 3μA. This greatly reduces the current drain on the battery and increases the standby time. The charging profile is shown in the following figure:



Programming charge current

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

$$R_{PROG} = \frac{1100}{I_{BAT}} (error \pm 10\%)$$

In application, according the charge current to determine R_{PROG} ,the relation between R_{PROG} and charge current can reference the following chart:

$K = \frac{1100}{R_{PROG} \times I_{BAT}}$	I_{BAT} (mA)	R_{PROG} (KΩ)
0.9	30	40
0.75	60	24
0.8	114	12
0.9	305	4
1	650	1.7
1.1	1000	1

Note:

a. K is the coefficient of variation, It generally is 1, but due to the vary operating environment, K is varied in the range: 0.8~1.4

b. The up form is just for reference, it will varied ±10% according to the heat dissipation of the using PCB board;

c. The footprint copper pads should be as wide as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient.

Charge termination

A charge cycle is terminated when the charge current falls to $1/10^{th}$ 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 for longer than t_{TEMP} (typically 1.8mS), Charging is terminated. The charge current is latched off and the ME4064A enters standby mode, where the input supply current drops to 55μA (Note:C/10 termination is disabled in trickle charging and thermal limiting modes).

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 $1/10^{th}$ the programmed value. The 1.8mS filter time (t_{TEMP}) 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 $1/10^{th}$ the programmed value, the ME4064A terminated 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.

The ME4064A constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the 4.02V 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.

Charge Status Indicator (CHRG)

ME4064A has one open-drain status indicator output $\overline{CHRG}$.$\overline{CHRG}$ is pull-down when the ME4064A in a charge cycle. In other status $\overline{CHRG}$ in high impedance.

Represent in failure state, when the charger with no battery: LED don't light. If battery is not connected to charger, $\overline{CHRG}$ pin outputs a PWM level to indicate no battery. If BAT pin connects a 10μF capacitor, the frequency of $\overline{CHRG}$ flicker about 1-4S, If not use status indicator should set status indicator output connected to GND.

Thermal limiting

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 110℃ . The feature protects the ME4064A 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 ME4064A. 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.

Under Voltage lockout (UVLO)

An internal under voltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until VCC rises above the under voltage lockout threshold . If the UVLO comparator is tripped, the charger will not come out of shutdown mode until VCC rises 140mV above the battery voltage.

Manual terminate

At any time of the cycle of charging will put the ME4064A into disable mode to remove R_{PROG} （PROG pin is float）. This made the battery drain current to less than 2μA and reducing the supply current to 55μA. To restart the charge cycle, connect a programming resistor.

If ME4064A in the under voltage Lockout mode, the $\overline{CHRG}$ is in high impedance state, or VCC is above BAT pin 140mV, or V_{CC} is too low.

Auto restart

Once charge is been terminated, ME4064A immediately use a 1.8ms filter time（ $t_{RECHARGE}$ ）on the termination comparator to constant monitor the voltage on BAT pin. If this voltage drops below the 4.02V recharge threshold (about between 80% and 90% of V_{CC}), another charge cycle begins. This ensured the battery maintained (or approach) to a charge full status and avoid the requirement of restarting the periodic charging cycle. In the recharge cycle, $\overline{CHRG}$ pin enters a pulled down status.

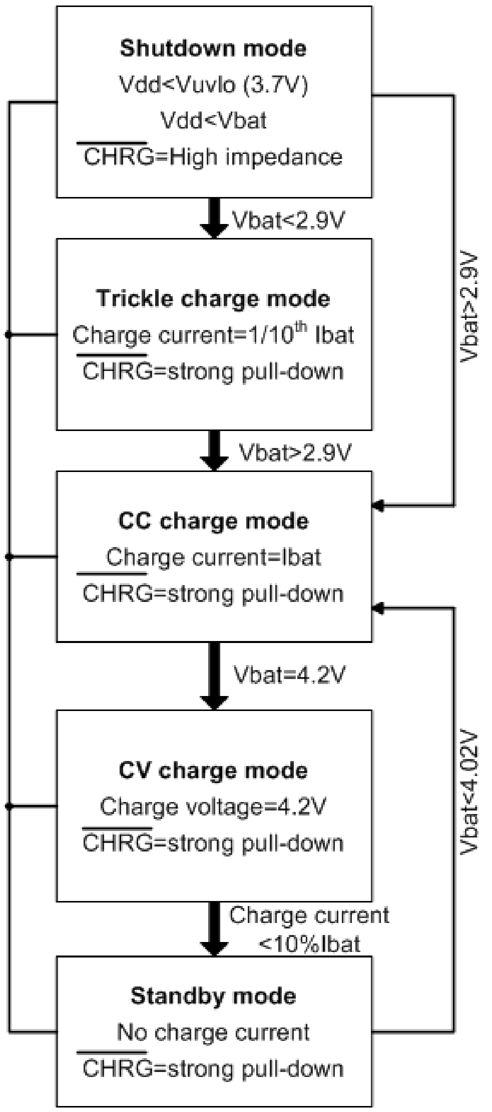


Fig.1 State diagram of a typical charge cycle

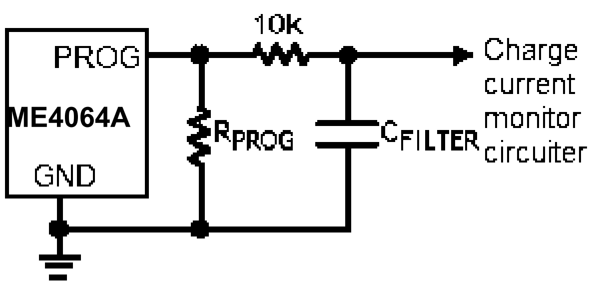


Fig.2 Isolating with capacitive load on PROG Pin

Stability Considerations

In constant-current mode, the PROG pin is in the feedback loop, not the battery. The constant-current mode stability is affected by the impedance at the PROG pin. With no additional capacitance on the PROG pin, the charger is stable with program resistor values as high as 20KΩ. However, additional capacitance on this node reduces the maximum allowed program resistor. Therefore, if I_{PROG} pin is loaded with a capacitance C, the following equation should be used to calculate the maximum resistance value for R_{PROG}:

$$R_{PROG} \le \frac{1}{2\pi \bullet 10^5 \bullet C_{PROG}}$$

As user, may think charge current is important, not instantaneous current. For example, to run a low current mode switch power which parallel connected with battery, the average current from BAT pin usually importance to instantaneous current. In this case, In order to measure average charge current or isolate capacitive load from I_{PROG} pin, a simple RC filter can be used on PROG pin as shown in Figure 2. In order to ensure the stability add a 10KΩ resistor between PROG pin and filter capacitor.

Power dissipation

The conditions that cause the ME4064A to reduce charge current through thermal feedback can be approximated by considering the power dissipated in the IC. Nearly all of this power dissipation is generated by the internal MOSFET-this is calculated to be approximately: $P_D = (V_{CC} - V_{BAT}) \times I_{BAT}$

The approximate ambient temperature at which the thermal feedback begins to protect the IC is:

$$T_A = 110°C - P_D\theta_{JA}\ ; \qquad T_A = 110°C - (V_{CC} - V_{BAT}) \times I_{BAT} \times \theta_{JA}$$

For example: The ME4064A with 5V supply voltage through programmable provides full limiting current 800mA to a charge lithium-ion battery with 3.75V voltage. If θ_{JA} is 150℃/W (reference to PCB layout considerations), When ME4064A begins to decrease the charge current, the ambient temperature about:

$$T_A = 110°C - (5V - 3.75V) \times (800mA) \times 150°C / W$$

$$T_A = 110°C - 0.5W \times 150°C / W = 110°C - 75°C \qquad T_A = 35°C$$

ME4064A can work in the condition of the temperature is above 35℃, but the charge current will pull down to below 800mA. In a fixed ambient temperature, the charge current is calculated to be approximately :

$$I_{BAT} = \frac{110℃ - T_A}{(VCC - V_{BAT}) * \theta_{JA}}$$

Just as Description of the Principle part talks about so, the current on PROG pin will reduce in proportion to the reduced charge current through thermal feedback. In ME4064A design applications don't need to considerate the worst case of thermal condition, this point is importance, because if the junction temperature up to 110℃ ,IC will auto reduce the power dissipation.

Thermal considerations

Because of the small size of the thin SOT23-5 package, it is important to use a good thermal PC board layout to maximize the available charge current. The thermal path for the heat generated by the IC is from the die to the copper lead frame, through the package leads, (especially the ground lead) to the PC board copper. The PC board copper is the heat sink. The footprint copper pads should be as wide as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient. Other heat sources on the board, not related to the charger, must also be considered when designing a PC board layout because they will affect overall temperature rise and the maximum charge current.

Add thermal regulation current

It will effective to decrease the power dissipation through reduce the voltage of both ends of the inner MOSFET. In the thermal regulation, this action of transporting current to battery will raise. One of the measure is through an external component(as a resistor or diode) to consume some power dissipation.

For example: The ME4064A with 5V supply voltage through programmable provides full limiting current 800mA to a charge lithium-ion battery with 3.75V voltage. If θ_{JA} is 105℃/W, so that at 25℃ ambient temperature, the charge current is calculated to be approximately : $I_{BAT} = \frac{110℃ - 25℃}{(Vs - I_{BAT} * Rcc - V_{BAT}) * \theta_{JA}}$

In order to increase the thermal regulation charge current, can decrease the power dissipation of the IC through reducing the voltage (as show fig.3) of both two ends of the resistor which connecting in series with a 5V AC adapter. With square equation to calculate I_{BAT} :

$$I_{BAT} = \frac{(Vs - V_{BAT}) - \sqrt{(Vs - V_{BAT})^2 - \frac{4Rcc(110℃ - T_A)}{\Theta_{JA}}}}{2Rcc}$$

If R_{CC}=0.25Ω, V_S=5V, V_{BAT}=3.75V, T_A=25℃ and θ_{JA} =105℃/W, we can calculate the thermal regulation charge current: I_{BAT}=764mA. It means that in this structure it can output 800mA full limiting charge current at more high ambient temperature environment.

Although it can transport more energy and reduce the charge time in this application, but actually spread charge time, if ME4064A stay in under-voltage state, when V_{CC} becomes too low in voltage mode. Fig.4 shows how the voltage reduced with increase R_{CC} value in this circuit. This technique will act the best function when in order to maintain the minimize the dimension of the components and avoid voltage decreased to minimize R_{CC} .

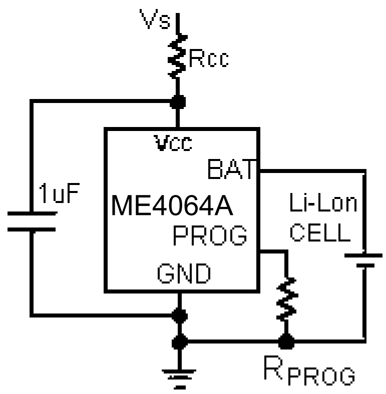


Fig.3:A circuit to maximum the thermal regulation charge current

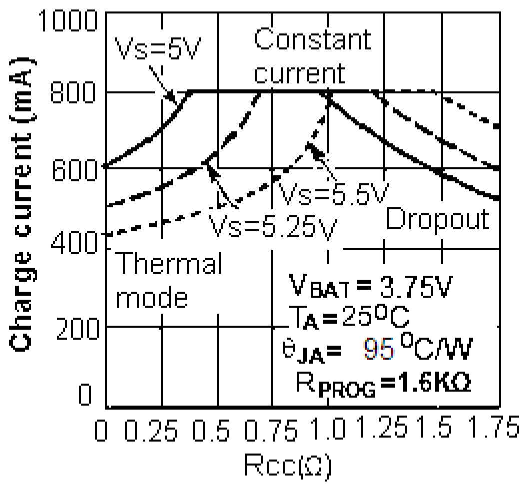


Fig.4:The relationship curve between charge current with R_{CC}

V_{CC} bypass capacitor

Many types of capacitors can be used for input bypassing, however, caution must be exercised when using multilayer ceramic capacitors. Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, high voltage transients can be generated under some start-up conditions, such as connecting the charger input to a live power source. Adding a 1.5Ω resistor in series with a ceramic capacitor will minimize start-up voltage transients.

Charging Current Soft Start

ME4064A includes a soft start circuit which used to maximize to reduce the surge current in the begging of charge cycle. When restart a new charge cycle, the charging current ramps up from 0 to the full charging current within 20μs. In the start process it can maximize to reduce the action which caused by surge current load.

USB and Wall Adapter Power

ME4064A allows charging from a USB port, a wall adapter can also be used to charge Li-Ion/Li-polymer batteries. Figure 5 shows an example of how to combine wall adapter and USB power inputs. A P-channel MOSFET, M1, is used to prevent back conducting into the USB port when a wall adapter is present and Schottky diode, D1, is used to prevent USB power loss through the 1KΩ pull-down resistor.

Generally, AC adaptor is able to provide bigger much current than the value of specific current limiting which is 500mA for USB port. So can rise charge current to 600mA with using a N-MOSFET (MN1) and an additional set resistor value as high as 10KΩ.

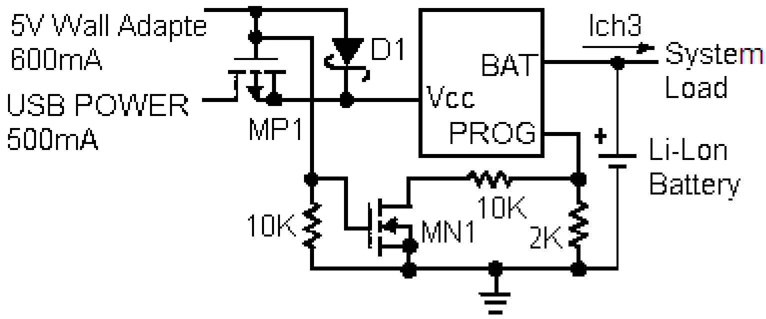
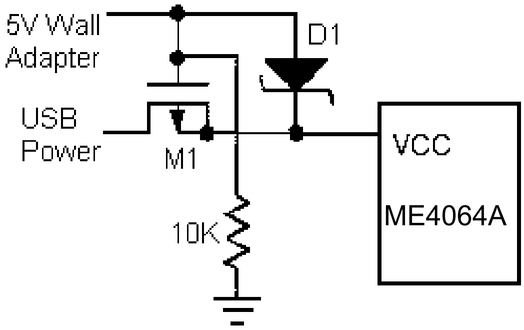


Fig.5:Combining Wall Adapter and USB Power

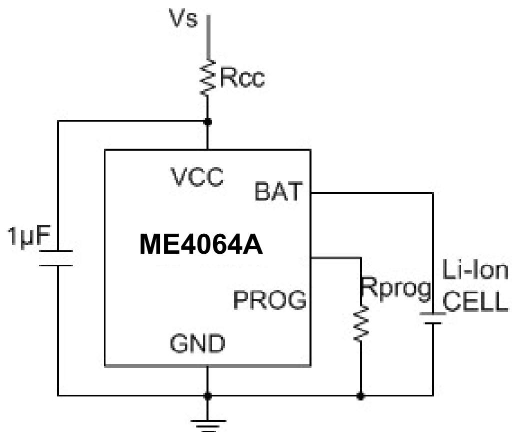
Typical Application

Mainly used in Cellular telephones, MP3, MP4 players, digital still cameras, electronic dictionary, GPS, portable devices and vary chargers.

1. Suitable for the application of USB power and the charge of wall adapter



2. Add a resistor for power dissipation



Board Layout Considerations

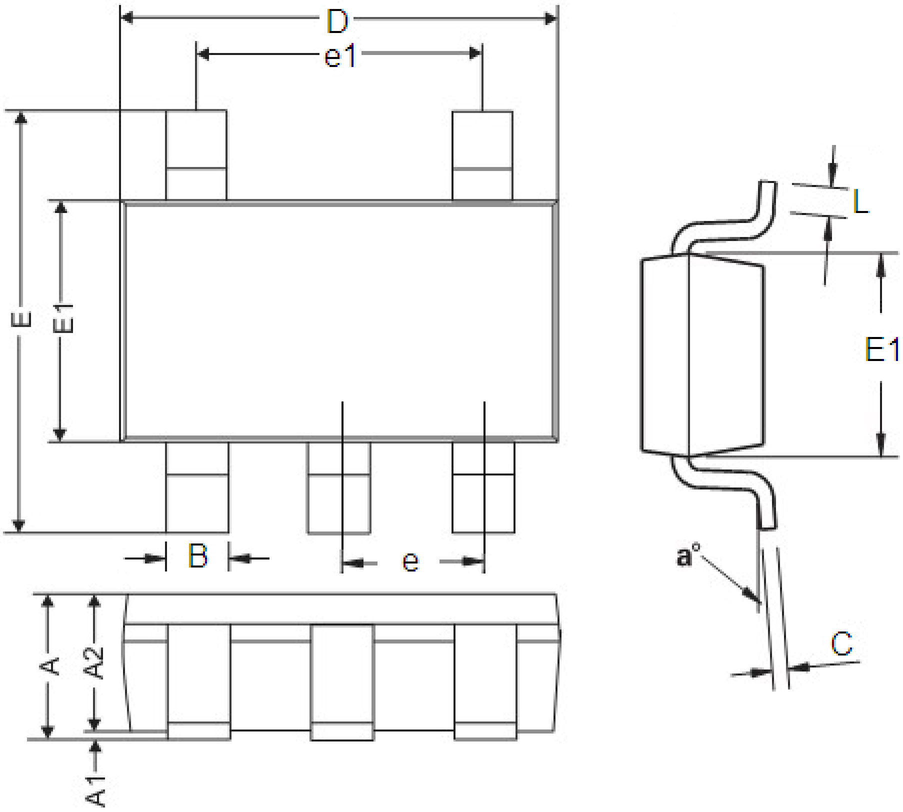
●R_{PROG} at PROG pin should be as close to ME4064A as possible, also the parasitic capacitance at PROG pin should be kept as small as possible.

●The capacitance at V_{CC} pin and BAT pin should be as close to ME4064A as possible.

● It is very important to use a good thermal PC board layout to maximize charging current. The thermal path for the heat generated by the IC is from the die to the copper lead frame through the package lead (especially the ground lead) to the PC board copper, the PC board copper is the heat sink. The footprint copper pads should be as wide as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient. Feed through vias to inner or backside copper layers are also useful in improving the overall thermal performance of the charger. Other heat sources on the board, not related to the charger, must also be considered when designing a PC board layout because they will affect overall temperature rise and the maximum charge current.

●The ability to deliver maximum charge current under all conditions require that the exposed metal pad on the back side of the ME4064A package be soldered to the PC board ground. Failure to make the thermal contact between the exposed pad on the backside of the package and the copper board will result in larger thermal resistance.

Packaging Information:



Package type:SOT23-5 Unit:mm(inch)

DIM	Millimeters		Inches	
	Min	Max	Min	Max
A	0.9	1.45	0.0354	0.0570
A1	0	0.15	0	0.0059
A2	0.9	1.3	0.0354	0.0511
B	0.2	0.5	0.0078	0.0196
C	0.09	0.26	0.0035	0.0102
D	2.7	3.10	0.1062	0.1220
E	2.2	3.2	0.0866	0.1181
E1	1.30	1.80	0.0511	0.0708
e	0.95REF		0.0374REF	
e1	1.90REF		0.0748REF	
L	0.10	0.60	0.0039	0.0236
a^0	0^0	30^0	0^0	30^0

800mA Lithium Ion Battery Linear Charger ME4055A

General Description

ME4055A is a complete constant-current/constant voltage linear charger for single cell lithium-ion batteries. Furthermore the ME4055A is specifically designed to work within USB power specifications.

No external sense resistor is needed and no blocking diode is required due to the internal PMOSFET 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 ME4055A automatically terminates the charge cycle when the charge current drops to 1/10th the programmed value after the final float voltage is reached.

When the input supply (wall adapter or USB supply) is removed the ME4055A automatically enters a low current state dropping the battery drain current to less than 2μA.The ME4055A can be put into shutdown mode reducing the supply current to 55μA.

Other features include charge current monitor, undervoltage lockout, automatic recharge and a status.

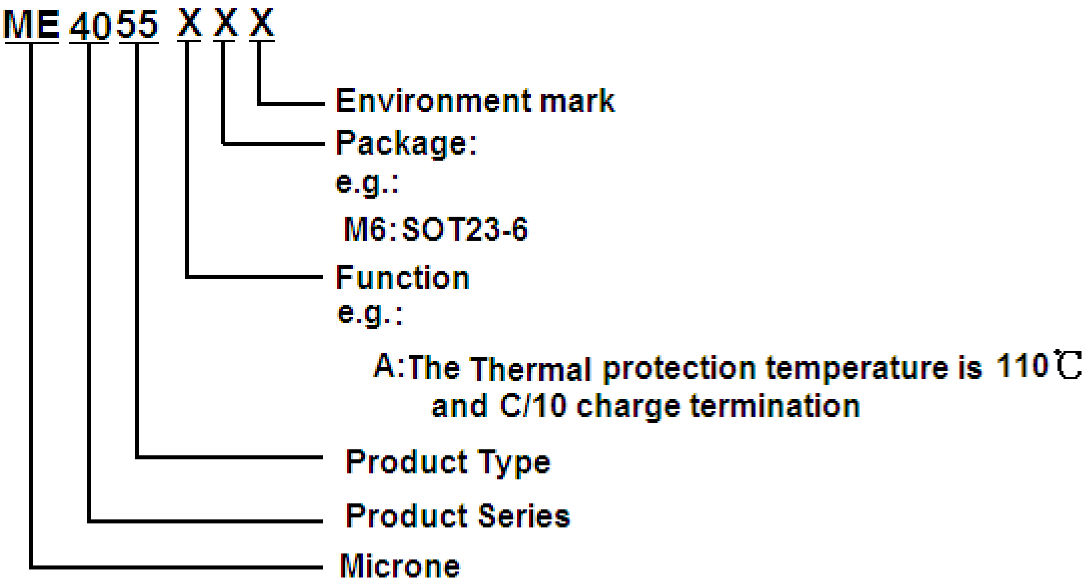
Features

- ●Protection of battery cell reverse connection
- ●No MOSFET sense resistor or blocking diode required
- ●Complete Linear Charger in Thin SOT Package for Single Cell Lithium-Ion Batteries
- ●Constant- Current/Constant- Voltage operation with thermal regulation to maximize Rate Without risk of overheating.
- ● Preset 4.2V charge voltage with ±1% accuracy
- ● Automatic Recharge
- ●Charges Single Cell Li-Ion Batteries Directly from USB Port
- ●C/10 charge termination
- ● 55μA supply current in shutdown
- ● 2.9V trickle current charge threshold
- ● Soft-Start limits inrush current
- ●Charge Status Output Pin
- ●Available in SOT23-6 Package

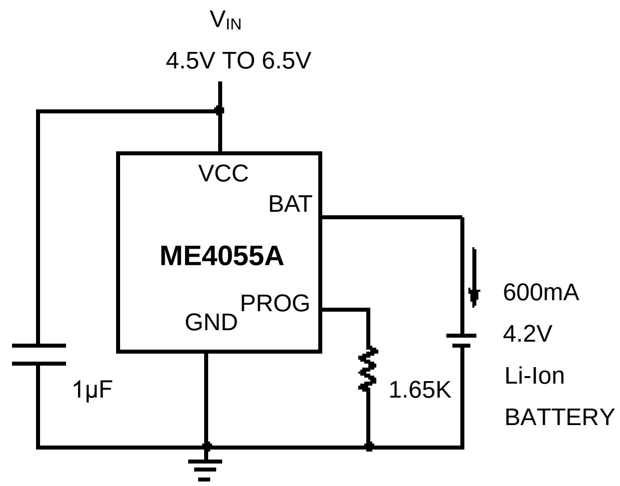
Applications

- ●Cellular Telephones, PDAs, MP3 Players
- ●Charging Docks and Cradles
- ●Bluetooth Applications

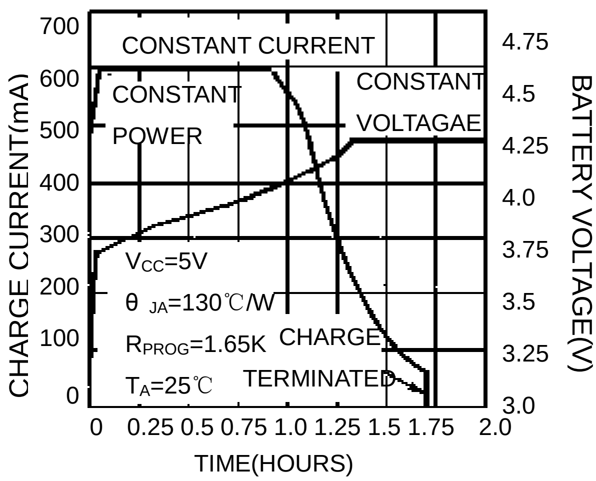
Selection Guide



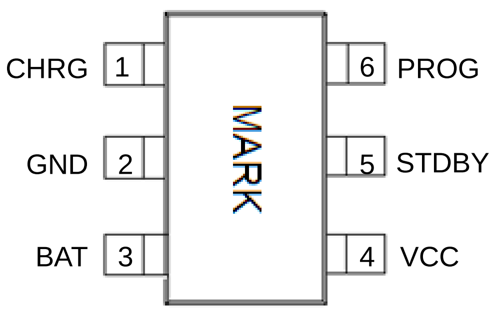
600mA Single Cell Li-Ion Charger



Typical charge cycle（750mAh batter



Pin Configuration



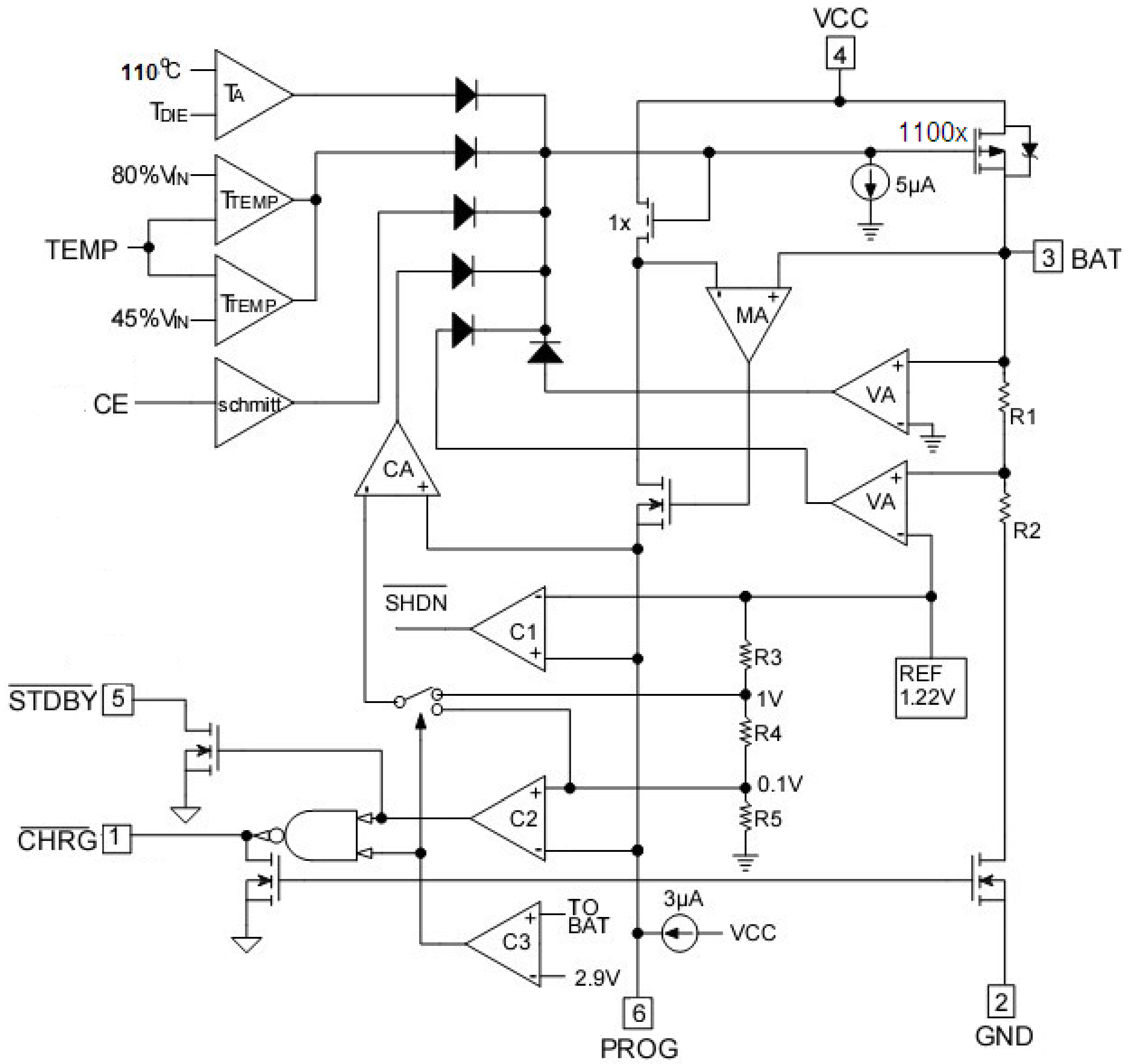
Package type: SOT23-6

Pin Assignment

ME4055AM6G

Pin Num.	Symbol	Function
1	CHRG	**Open-Drain charge status output** When the battery is being charged, the $\overline{CHRG}$ pin is pulled low by an internal switch, otherwise, $\overline{CHRG}$ pin is in high impedance state.
2	GND	**Ground**
3	BAT	**Battery connection Pin** Connect the positive terminal of the battery to this pin. Dropping BAT pin's current to less than 2μA when IC in disable mode or in sleep mode. BAT pin provides charge current to the battery and provides regulation voltage of 4.2V.
4	VCC	**Positive input supply voltage** Provides power to the internal circuit. When V_{CC} drops to within 80mV of the BAT pin voltage, the ME4055A enters low power sleep mode, dropping I_{BAT} to less than 2μA.
5	STDBY	**Charge terminated status output** STDBY is pulled low by an internal switch to indicate a battery charge terminated; this means Charge termination. Otherwise STDBY pin is in high impedance state.
6	PROG	**Constant Charge Current Setting and Charge Current Monitor Pin** The charge current is programmed by connecting a resistor R_{PROG} from this pin to GND. When in precharge mode, the PROG pin's voltage is regulated to 0.1V. When charging in constant-current mode this pin's voltage is regulated to 1V. In all modes during charging, the voltage on this pin can be used to measure the charge current using the following formula: $I_{BAT} = \frac{V_{PROG}}{R_{PROG}} * 1100$

Block Diagram



Absolute Maximum Ratings

Parameter	Rating	Unit
Input supply voltage : V_{CC}	-0.3～6.5	V
PROG pin voltage	-0.3～VCC+0.3	V
BAT pin voltage	-0.3～6.5	V
$\overline{CHRG}$ pin voltage	-0.3～6.5	V
$\overline{STDBY}$ pin voltage	-0.3～6.5	V
BAT pin current	800	mA
PROG pin current	1200	μA
Maximum junction temperature	145	℃
Operating ambient temperature :T_{opa}	-40～85	℃
Storage temperature :T_{str}	-65～125	℃
Soldering temperature and time	+260（Recommended 10S）	℃

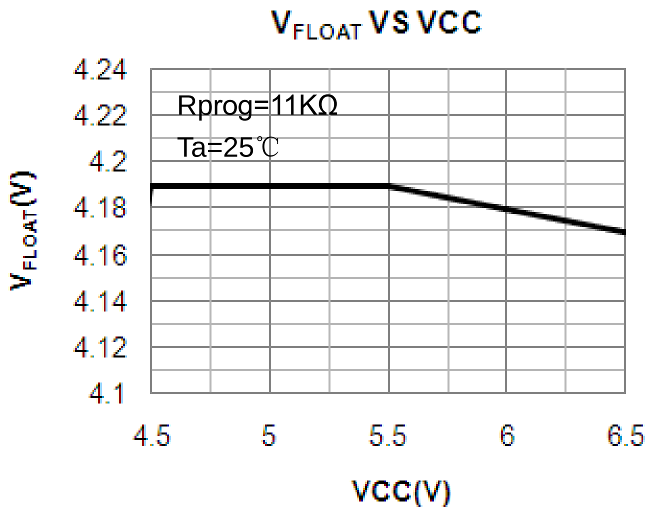
Caution: The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.

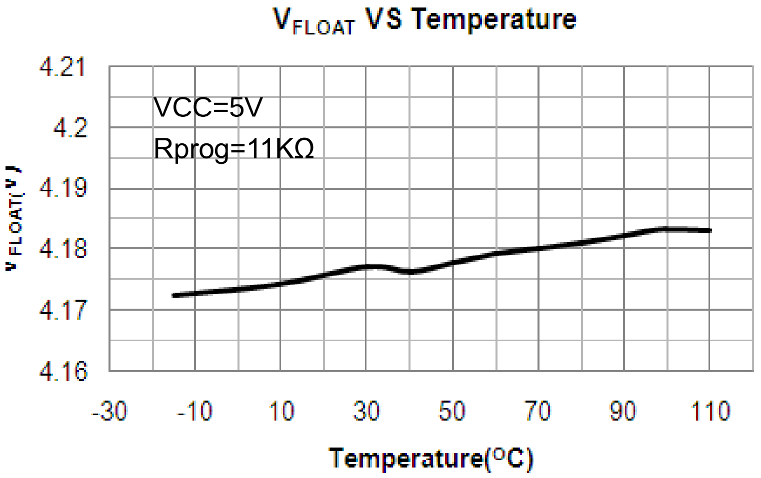
Electrical Characteristics

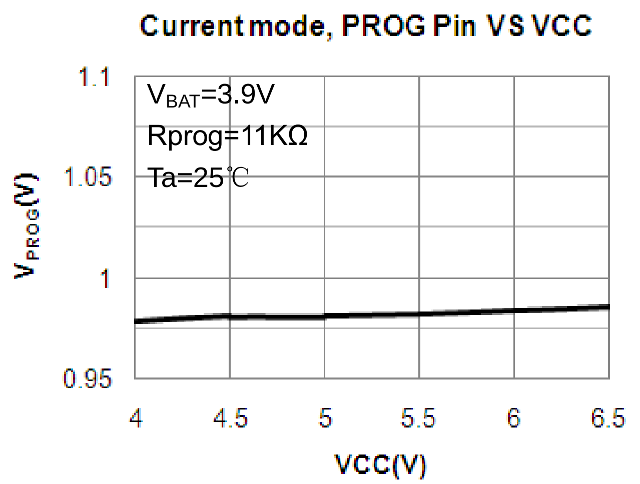
Symbol	Parameter	Condition	Min	Typ.	Max	Unit
V_{CC}	Input supply voltage	●	4.0	5.0	6.5	V
I_{CC} -I_{BAT}	static current	●Charge mode, R_{PROG}=1.1KΩ	-	150	500	μA
		●Standby mode(charge end)	-	55	100	μA
		●Shutdown mode（R_{PROG} not connected, V_{CC}<V_{BAT}, or V_{CC}<V_{UV}）	-	55	100	μA
V_{FLOAT}	Regulated output voltage	0℃≤T_A≤85℃	4.158	4.2	4.242	V
I_{BAT}	BAT pin current (The condition of current mode is V_{BAT}=3.9V)	●R_{PROG}=2.2KΩ, current mode	450	500	550	mA
		●R_{PROG}=1.1KΩ,current mode	950	1000	1050	mA
		●Standby mode: V_{BAT}=4.2V	0	-2.5	-6	μA
		Shutdown mode, R_{PROG} not connected	-	±1	±2	μA
		Sleep mode, V_{CC}=0V	-	-1	-2	μA
I_{TRIKL}	Trickle charge current	●V_{BAT}<V_{TRIKL}, R_{PROG}=1.1KΩ	120	130	140	mA
V_{TRIKL}	Trickle charge threshold voltage	R_{PROG}=1.1KΩ, V_{BAT} rising	2.8	2.9	3.0	V
V_{TRHYS}	Trickle voltage hysteresis voltage	R_{PROG}=1.1KΩ	150	200	250	mV
V_{UV}	V_{CC} under voltage lockout threshold	● V_{CC} from low to high	3.5	3.7	3.9	V
V_{UVHYS}	V_{CC} under voltage lockout hysteresis	●	150	200	300	mV
V_{ASD}	V_{CC}-V_{BAT} lockout threshold voltage	V_{CC} from low to high	100	140	180	mV
		V_{CC} from high to low	50	80	110	
I_{TERM}	termination current threshold	●R_{PROG}=2.2KΩ	60	70	80	mA
		●R_{PROG}=1.1KΩ	120	130	140	
V_{PROG}	PROG pin voltage	●R_{PROG}=1.1KΩ, current mode	0.9	1.0	1.1	V
V_{CHRG}	$\overline{CHRG}$ Pin output low voltage	$I_{\overline{CHRG}}$ =5mA	-	0.3	0.6	V
ΔV_{RECHRG}	Recharge battery threshold voltage	V_{FLOAT} -V_{RECHRG}	120	180	240	mV
T_{LIM}	Thermal protection temperature		-	110	-	℃
R_{ON}	The resistance of power FET ”ON”（between V_{CC} and BAT）		-	650	-	mΩ
t_{SS}	Soft-start time	I_{BAT}=0 to I_{BAT}=1100V/R_{PROG}	-	20	-	μS
$t_{RECHARGE}$	Recharge comparator filter time	V_{BAT} from high to low	0.8	1.8	4	mS
t_{TERM}	Termination comparator filter time	I_{BAT} below I_{CHG}/10	0.8	1.8	4	mS
I_{PROG}	PROG pin pull-up current		-	2.0	-	μA

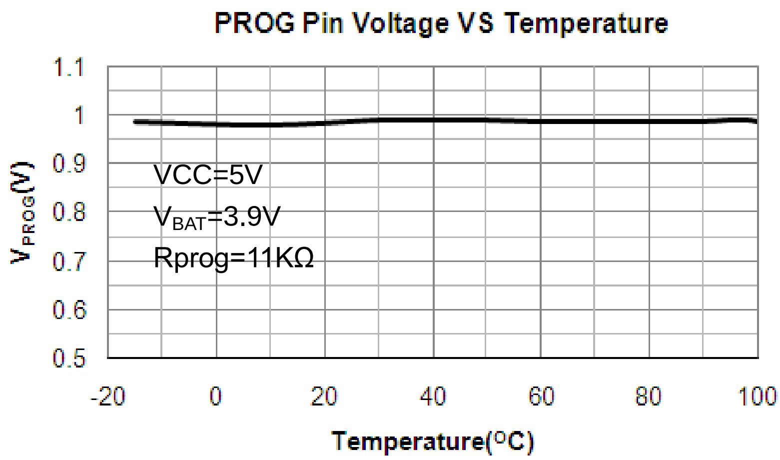
Note: The ● denotes specifications which apply over the full operating temperature rang, otherwise specifications are at T_A=25℃，V_{CC}=5V，unless otherwise specified.

Typical performance characteristics







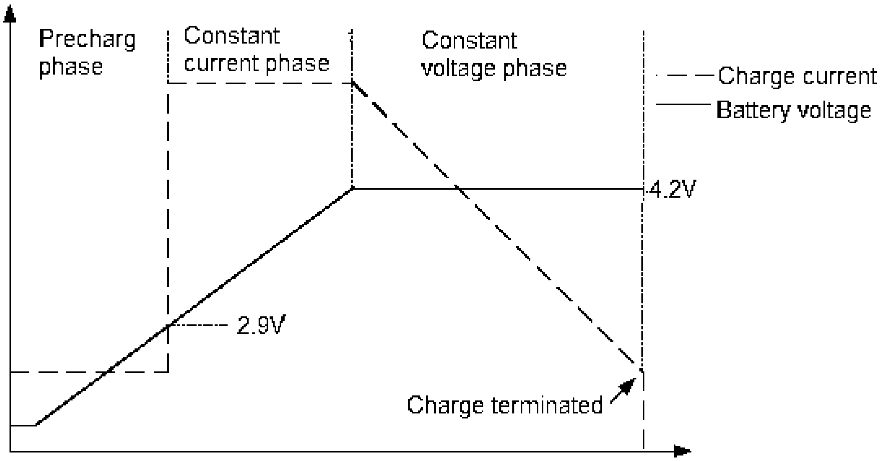


Description of the Principle

The ME4055A is a complete constant-current/constant-voltage linear charger for single cell lithium-ion batteries. Constant-current/constant-voltage to charger batter by internal MOSFET .It can deliver up to 800mA of charge current .No blocking diode or external current sense resistor is required. ME4055A include one Open-Drain charge status Pin: Charge status indicator $\overline{CHRG}$

The internal thermal regulation circuit reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 110℃. This feature protects the ME4055A 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 ME4055A or the external components. Another benefit of adopting thermal regulation is that charge current can be set according to typical, not worst-case, ambient temperatures for a given application with the assurance that the charger will automatically reduce the current in worst-case conditions.

The charge cycle begins when the voltage at the V_{CC} pin rises above the UVLO level, a current set resistor is connected from the PROG pin to ground. The $\overline{CHRG}$ pin outputs a logic low to indicate that the charge cycle is on going. At the beginning of the charge cycle, if the battery voltage is below 2.9V, the charge is in precharge mode to bring the cell voltage up to a safe level for charging. The charger goes into the fast charge constant-current mode once the voltage on the BAT pin rises above 2.9 V. In constant current mode, the charge current is set by R_{PROG}. When the battery approaches the regulation voltage 4.2V, the charge current begins to decrease as the ME4055A enters the constant-voltage mode. When the current drops to charge termination threshold, the charge cycle is terminated, and $\overline{CHRG}$ pin assumes a high impedance state to indicate that the charge cycle is terminated . The charge termination threshold is 10% of the current in constant current mode. To restart the charge cycle, remove the input voltage and reapply it . The charge cycle can also be automatically restarted if the BAT pin voltage falls below the recharge threshold. The on-chip reference voltage, error amplifier and the resistor divider provide regulation voltage with 1% accuracy which can meet the requirement of lithium-ion and lithium polymer batteries. When the input voltage is not present, or input voltage is below V_{BAT}, the charger goes into a sleep mode, dropping battery drain current to less than 3μA. This greatly reduces the current drain on the battery and increases the standby time. The charging profile is shown in the following figure:



Programming charge current

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

$$R_{PROG} = \frac{1100}{I_{BAT}} (\text{error} \pm 10\%)$$

In application, according the charge current to determine R_{PROG} ,the relation between R_{PROG} and charge current can reference the following chart:

$K = \frac{1100}{R_{PROG} \times I_{BAT}}$	I_{BAT} (mA)	R_{PROG} (KΩ)
0.9	30	40
0.75	60	24
0.8	114	12
0.9	305	4

1	650	1.7
1.1	1000	1

Note:

a. K is the coefficient of variation, It generally is 1, but due to the vary operating environment, K is varied in the range: 0.8~1.4

b. The up form is just for reference, it will varied ±10% according to the heat dissipation of the using PCB board;

c. The footprint copper pads should be as wide as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient.

Charge termination

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 for longer than t_{TEMP} (typically 1.8mS), Charging is terminated. The charge current is latched off and the ME4055A enters standby mode, where the input supply current drops to 55μA (Note:C/10 termination is disabled in trickle charging and thermal limiting modes).

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 1.8mS filter time (t_{TEMP}) 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 ME4055A terminated 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.

The ME4055A constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the 4.02V 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.

Charge status indicator

ME4055A has two open-drain status indicator output $\overline{CHRG}$ and $\overline{STDBY}$.$\overline{CHRG}$ is pull-down when the ME4055A in a charge cycle. In other status $\overline{CHRG}$ in high impedance. $\overline{CHRG}$ and $\overline{STDBY}$ are all in high impedance when the battery out of the normal temperature.

Represent in failure state, when TEMP pin in typical connecting, or the charger with no battery: red LED and green LED all don't light. The battery temperature sense function is disabled by connecting TEMP pin to GND. If battery is not connected to charger, $\overline{CHRG}$ pin outputs a PWM level to indicate no battery. If BAT pin connects a 10μF capacitor, the frequency of $\overline{CHRG}$ flicker about 1-4S, If not use status indicator should set status indicator output connected to GND.

charger's status	Red led $\overline{CHRG}$	Green led $\overline{STDBY}$
Charging	light	dark
Battery in full state	dark	light
Under-voltage, battery's temperature is to high or too low, or not connect to battery(use TEMP)	dark	dark
BAT pin is connected to 10μF capacitor，No battery mode (TEMP=GND)	Green LED bright, Red LED flicker F=1-4 S（At this time, reverse-battery, the light does not shine, this phenomenon is normal. Such a case, after the battery is properly connected to the indicator light back to light and flicker.）	

Thermal limiting

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 110℃ . The feature protects the ME4055A 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 ME4055A. 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.

Under Voltage lockout (UVLO)

An internal under voltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until VCC rises above the under voltage lockout threshold . If the UVLO comparator is tripped, the charger will not come out of shutdown mode until V_{CC} rises 140mV above the battery voltage.

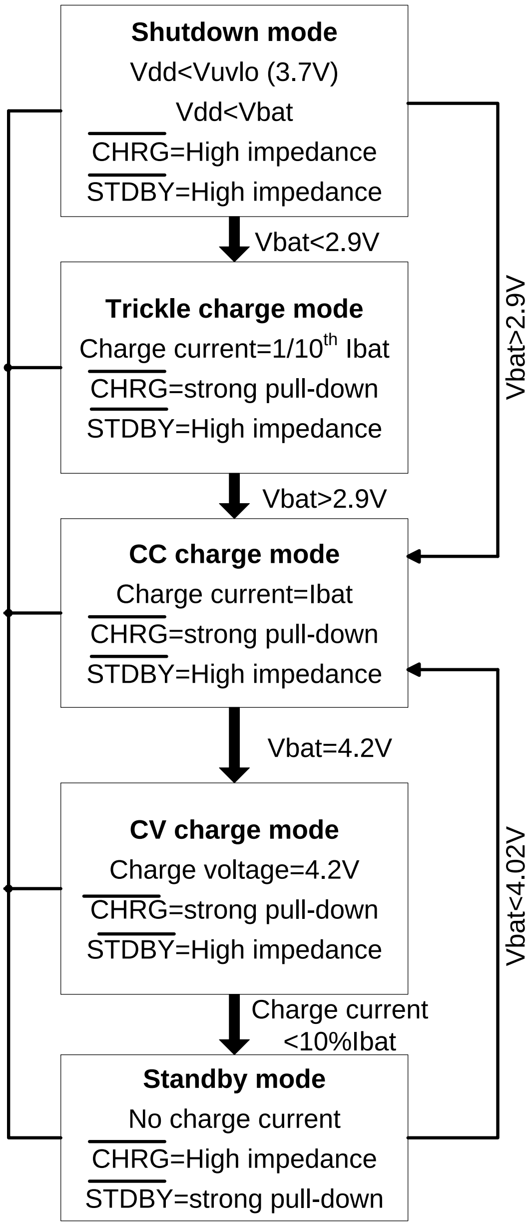
Manual terminate

At any time of the cycle of charging will put the ME4055A into disable mode to remove R_{PROG} （PROG pin is float）. This made the battery drain current to less than 2μA and reducing the supply current to 55μA. To restart the charge cycle, connect a programming resistor.

If ME4055A in the under voltage Lockout mode, the $\overline{CHRG}$ is in high impedance state, or VCC is above BAT pin 140mV, or V_{CC} is too low.

Auto restart

Once charge is been terminated, ME4055A immediately use a 1.8ms filter time（ $t_{RECHARGE}$ ）on the termination comparator to constant monitor the voltage on BAT pin. If this voltage drops below the 4.02V recharge threshold (about between 80% and 90% of V_{CC}), another charge cycle begins. This ensured the battery maintained (or approach) to a charge full status and avoid the requirement of restarting the periodic charging cycle. In the recharge cycle, $\overline{CHRG}$ pin enters a pulled down status.



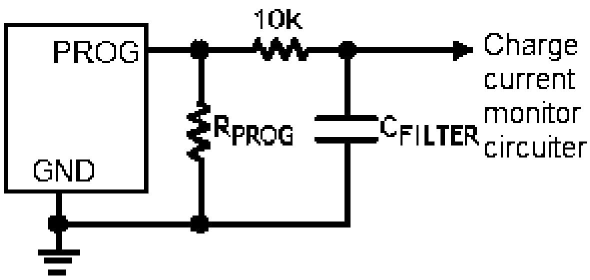


Fig.1 State diagram of a typical charge cycle

Fig.2 Isolating with capacitive load on PROG Pin

Stability Considerations

In constant-current mode, the PROG pin is in the feedback loop, not the battery. The constant-current mode stability is affected by the impedance at the PROG pin. With no additional capacitance on the PROG pin, the charger is stable with program resistor values as high as 20KΩ. However, additional capacitance on this node reduces the maximum allowed program resistor. Therefore, if I_{PROG} pin is loaded with a capacitance C, the following equation should be used to calculate the maximum resistance value for R_{PROG}:

$$R_{PROG} \le \frac{1}{2\pi \bullet 10^5 \bullet C_{PROG}}$$

As user, may think charge current is important, not instantaneous current. For example, to run a low current mode switch power which parallel connected with battery, the average current from BAT pin usually importance to instantaneous current. In this case, In order to measure average charge current or isolate capacitive load from I_{PROG} pin, a simple RC filter can be used on PROG pin as shown in Figure 2. In order to ensure the stability add a 10KΩ resistor between PROG pin and filter capacitor.

Power dissipation

The conditions that cause the ME4055A to reduce charge current through thermal feedback can be approximated by considering the power dissipated in the IC. Nearly all of this power dissipation is generated by the internal MOSFET-this is calculated to be approximately: $P_D = (V_{CC} - V_{BAT}) \text{ X } I_{BAT}$

The approximate ambient temperature at which the thermal feedback begins to protect the IC is:

$$T_A = 110°C - P_D\theta_{JA}\,; \qquad T_A = 110°C - (V_{CC} - V_{BAT}) \text{ X } I_{BAT} \text{ X } \theta_{JA}$$

For example: The ME4055A with 5V supply voltage through programmable provides full limiting current 800mA to a charge lithium-ion battery with 3.75V voltage. If θ_{JA} is 150℃/W (reference to PCB layout considerations), When ME4055A begins to decrease the charge current, the ambient temperature about:

$$T_A = 110°C - (5V - 3.75V) \text{ X } (800mA) \times 150°C/W$$

$$T_A = 110°C - 0.5W \text{ X } 150°C/W = 110°C - 75°C \qquad T_A = 35°C$$

ME4055A can work in the condition of the temperature is above 35℃, but the charge current will pull down to below 800mA. In a fixed ambient temperature, the charge current is calculated to be approximately :

$$I_{BAT} = \frac{110℃ - T_A}{(VCC - V_{BAT}) * \theta_{JA}}$$

Just as Description of the Principle part talks about so, the current on PROG pin will reduce in proportion to the reduced charge current through thermal feedback. In ME4055A design applications don't need to considerate the worst case of thermal condition, this point is importance, because if the junction temperature up to 110℃ ,IC will auto reduce the power dissipation.

Thermal considerations

Because of the small size of the thin SOT23-6 package, it is important to use a good thermal PC board layout to maximize the available charge current. The thermal path for the heat generated by the IC is from the die to the copper lead frame, through the package leads, (especially the ground lead) to the PC board copper. The PC board copper is the heat sink. The footprint copper pads should be as wide as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient. Other heat sources on the board, not related to the charger, must also be considered when designing a PC board layout because they will affect overall temperature rise and the maximum charge current.

Add thermal regulation current

It will effective to decrease the power dissipation through reduce the voltage of both ends of the inner MOSFET. In the thermal regulation, this action of transporting current to battery will raise. One of the measure is through an external component(as a resistor or diode) to consume some power dissipation.

For example: The ME4055A with 5V supply voltage through programmable provides full limiting current 800mA to a charge lithium-ion battery with 3.75V voltage. If θ_{JA} is 105℃/W, so that at 25℃ ambient temperature, the charge current is calculated to be approximately : $I_{BAT} = \frac{110℃ - 25℃}{(Vs - I_{BAT} * Rcc - V_{BAT}) * \theta_{JA}}$

In order to increase the thermal regulation charge current, can decrease the power dissipation of the IC through reducing the voltage (as show fig.3) of both two ends of the resistor which connecting in series with a 5V AC adapter. With square equation to calculate I_{BAT} :

$$I_{BAT} = \frac{(Vs - V_{BAT}) - \sqrt{(Vs - V_{BAT})^2 - \frac{4Rcc(110℃ - T_A)}{\Theta_{JA}}}}{2Rcc}$$

If R_{CC}=0.25Ω, V_S=5V, V_{BAT}=3.75V, T_A=25℃ and θ_{JA} =105℃/W, we can calculate the thermal regulation charge current: I_{BAT}＝764mA. It means that in this structure it can output 800mA full limiting charge current at more high ambient temperature environment.

Although it can transport more energy and reduce the charge time in this application, but actually spread charge time, if ME4055A stay in under-voltage state, when V_{CC} becomes too low in voltage mode. Fig.4 shows how the voltage reduced with increase R_{CC} value in this circuit. This technique will act the best function when in order to maintain the minimize the dimension of the components and avoid voltage decreased to minimize R_{CC} .

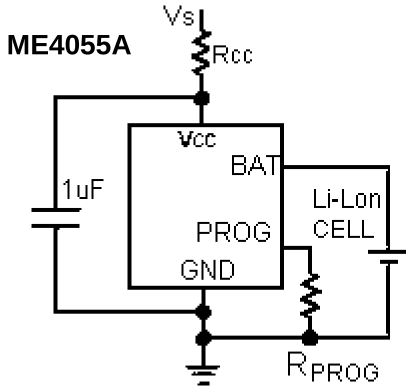


Fig.3:A circuit to maximum the thermal regulation charge current

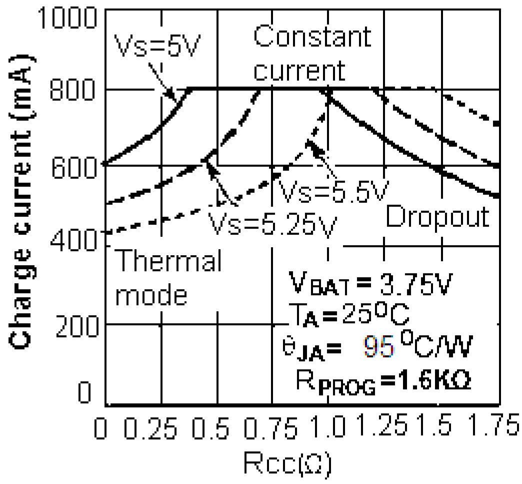


Fig.4:The relationship curve between charge current with R_{CC}

V_{CC} bypass capacitor

Many types of capacitors can be used for input bypassing, however, caution must be exercised when using multilayer ceramic capacitors. Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, high voltage transients can be generated under some start-up conditions, such as connecting the charger input to a live power source. Adding a 1.5Ω resistor in series with a ceramic capacitor will minimize start-up voltage transients.

Charging Current Soft Start

ME4055A includes a soft start circuit which used to maximize to reduce the surge current in the begging of charge cycle. When restart a new charge cycle, the charging current ramps up from 0 to the full charging current within 20μs. In the start process it can maximize to reduce the action which caused by surge current load.

USB and Wall Adapter Power

ME4055A allows charging from a USB port, a wall adapter can also be used to charge Li-Ion/Li-polymer batteries. Figure 5 shows an example of how to combine wall adapter and USB power inputs. A P-channel MOSFET, M1, is used to prevent back conducting into the USB port when a wall adapter is present and Schottky diode, D1, is used to prevent USB power loss through the 1KΩ pull-down resistor.

Generally, AC adaptor is able to provide bigger much current than the value of specific current limiting which is 500mA for USB port. So can rise charge current to 600mA with using a N-MOSFET (MN1) and an additional set resistor value as high as 10KΩ.

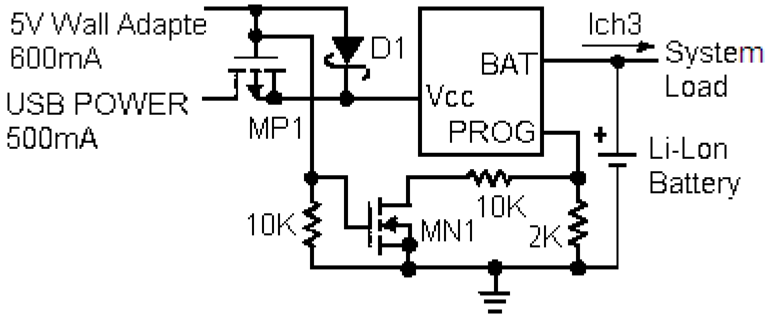
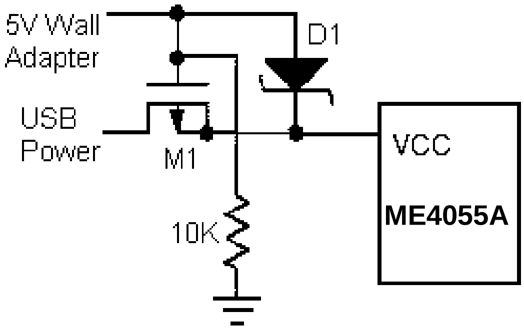


Fig.5:Combining Wall Adapter and USB Power

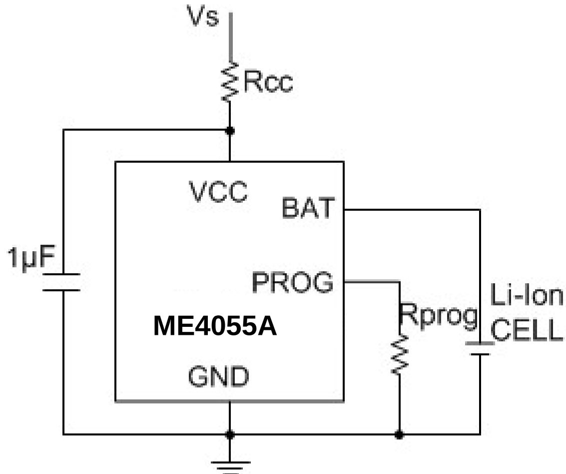
Typical Application

Mainly used in Cellular telephones, MP3, MP4 players, digital still cameras, electronic dictionary, GPS, portable devices and vary chargers.

1. Suitable for the application of USB power and the charge of wall adapter



2. Add a resistor for power dissipation

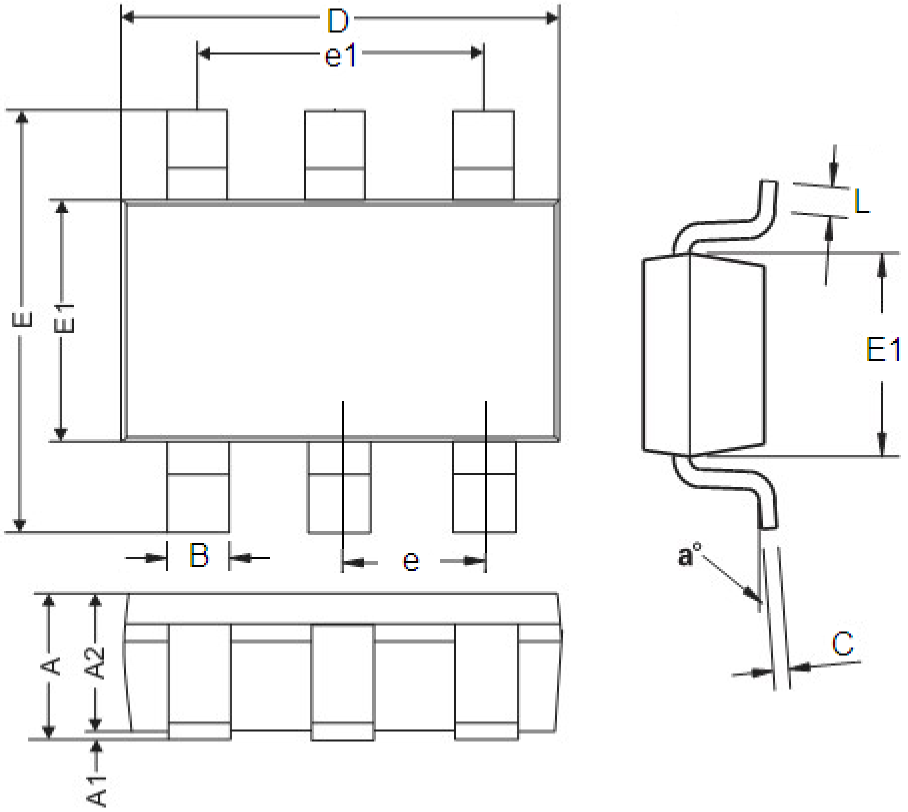


Board Layout Considerations

- R_{PROG} at PROG pin should be as close to ME4055A as possible, also the parasitic capacitance at PROG pin should be kept as small as possible.
- The capacitance at V_{CC} pin and BAT pin should be as close to ME4055A as possible.
- It is very important to use a good thermal PC board layout to maximize charging current. The thermal path for the heat generated by the IC is from the die to the copper lead frame through the package lead (especially the ground lead) to the PC board copper, the PC board copper is the heat sink. The footprint copper pads should be as wide as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient. Feed through vias to inner or backside copper layers are also useful in improving the overall thermal performance of the charger. Other heat sources on the board, not related to the charger, must also be considered when designing a PC board layout because they will affect overall temperature rise and the maximum charge current.
- The ability to deliver maximum charge current under all conditions require that the exposed metal pad on the back side of the ME4055A package be soldered to the PC board ground. Failure to make the thermal contact between the exposed pad on the backside of the package and the copper board will result in larger thermal resistance.

Packaging Information:

Package type:SOT23-6 Unit:mm(inch)



DIM	Millimeters		Inches	
	Min	Max	Min	Max
A	0.9	1.45	0.0354	0.0570
A1	0	0.15	0	0.0059
A2	0.9	1.3	0.0354	0.0511
B	0.2	0.5	0.0078	0.0196
C	0.09	0.26	0.0035	0.0102
D	2.7	3.10	0.1062	0.1220
E	2.2	3.2	0.0866	0.1181
E1	1.30	1.80	0.0511	0.0708
e	0.95REF		0.0374REF	
e1	1.90REF		0.0748REF	
L	0.10	0.60	0.0039	0.0236
a^0	0^0	30^0	0^0	30^0

1A Lithium Ion Battery Linear Charger ME4056

General Description

ME4056 is a complete constant-current/constant voltage linear charger for single cell lithium-ion batteries. With a thermally enhanced 8-PIN SOP package on the bottom and low external component count make the ME4056 ideally suited for portable applications. Furthermore the ME4056 is specifically designed to work within USB power specifications.

No external sense resistor is needed and no blocking diode is required due to the internal PMOSFET 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 ME4056 automatically terminates the charge cycle when the charge current drops to 1/10th the programmed value after the final float voltage is reached.

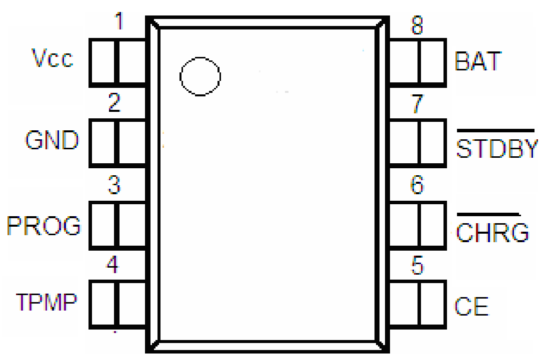
When the input supply (wall adapter or USB supply) is removed the ME4056 automatically enters a low current state dropping the battery drain current to less than 2μA.The ME4056 can be put into shutdown mode reducing the supply current to 55μA.

Other features include charge current monitor , under-voltage lockout, automatic recharge and a LED status pin to indicate charge termination and the presence of an input voltage.

Features

- ●Protection of battery cell reverse connection
- ● Programmable charge current up to 1A
- ●No MOSFET sense resistor or blocking diode required
- ●Complete linear Charger in SOP8 Package for single Cell Lithium-Ion Batteries.
- ●Constant-Current/Constant-Voltage operation with thermal regulation to maximize Rate Without risk of overheating.
- ● Preset 4.2V charge voltage with ±1.5% accuracy
- ● Automatic Recharge
- ● Two Status Indication for Charge status, no battery and battery failure indicators
- ● C/10 charge termination
- ● 55μA supply current in shutdown
- ● 2.9V trickle current charge threshold
- ● Soft-Start limits inrush current
- ● Battery Temperature Sensing
- ● Available in SOP8-PP package

Pin Configuration



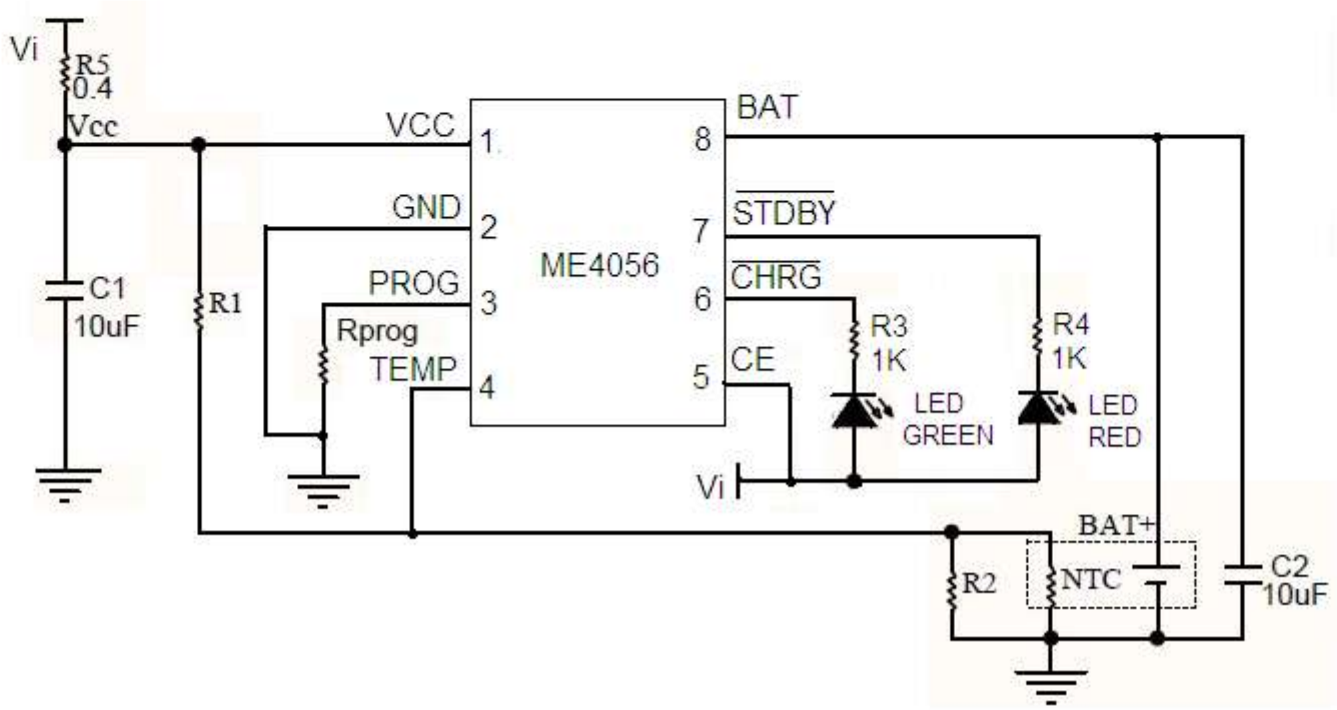
Pin Assignment

Pin Num.	Symbol	Function
1	V_{CC}	**Positive input supply voltage** Provides power to the internal circuit. When V_{CC} drops to within 30mV of the BAT pin voltage, the ME4056 enters low power sleep mode, dropping I_{BAT} to less than 2μA.
2	GND	**Ground**
3	PROG	**Constant Charge Current Setting and Charge Current Monitor Pin** The charge current is programmed by connecting a resistor R_{PROG} from this pin to GND. When in precharge mode, the PROG pin's voltage is regulated to 0.1V. When charging in constant-current mode this pin's voltage is regulated to 1V. In all modes during charging, the voltage on this pin can be used to measure the charge current using the following formula: $$I_{BAT} = \frac{V_{PROG}}{R_{PROG}} \times 1400$$
4	TEMP	**Temperature sense input** Connecting TEMP pin to NTC thermistor's output in Lithium ion battery pack. If TEMP pin's voltage is below 45% or above 80% of supply voltage V_{CC} for more than 0.15S, this means that battery's temperature is too high or too low, charging is suspended. The temperature sense function can be disabled by grounding the TEMP pin.
5	CE	**Chip enable input** A high input will put the device in the normal operating mode. Pulling the CE pin to low level will put the ME4056 into disable mode. The CE pin can be driven by TTL or CMOS logic level.
6	$\overline{CHRG}$	**Open-Drain charge status output** When the battery is being charged ,the $\overline{CHRG}$ pin is pulled low by an internal switch, otherwise, $\overline{CHRG}$ pin is in high impedance state.
7	$\overline{STDBY}$	**Open-Drain fault status output** When the voltage at TEMP pin is below 45% of V_{CC} or above 80% of V_{CC}, this means that battery's temperature is too high or too low, $\overline{STDBY}$ is pulled low by an internal switch to indicate a battery fault state; Otherwise $\overline{STDBY}$ pin is in high impedance state.
8	BAT	**Battery connection Pin** Connect the positive terminal of the battery to this pin. Dropping BAT pin's current to less than 2μA when IC in disable mode or in sleep mode. BAT pin provides charge current to the battery and provides regulation voltage of 4.2V.

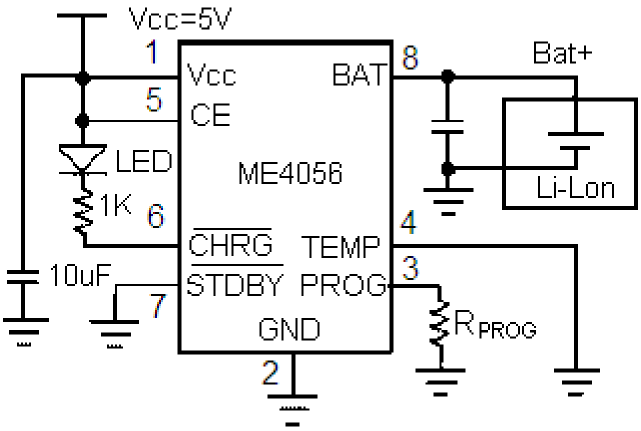
Typical Application

Mainly used in Cellular telephones, MP3, MP4 players, digital still cameras, electronic dictionary, GPS, portable devices and vary chargers.

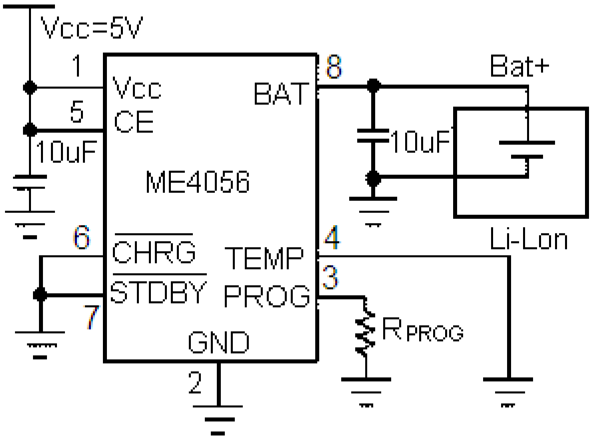
1. **Suitable for the function of battery's temperature detection, the application of the indicator of battery's temperature anomaly and charge status.**



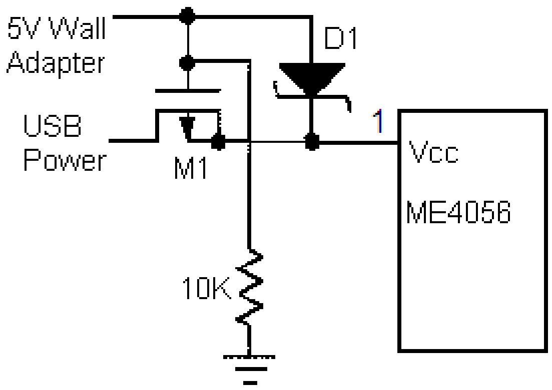
2. Suitable for charge status indicator, which the application not need battery's temperature detection.



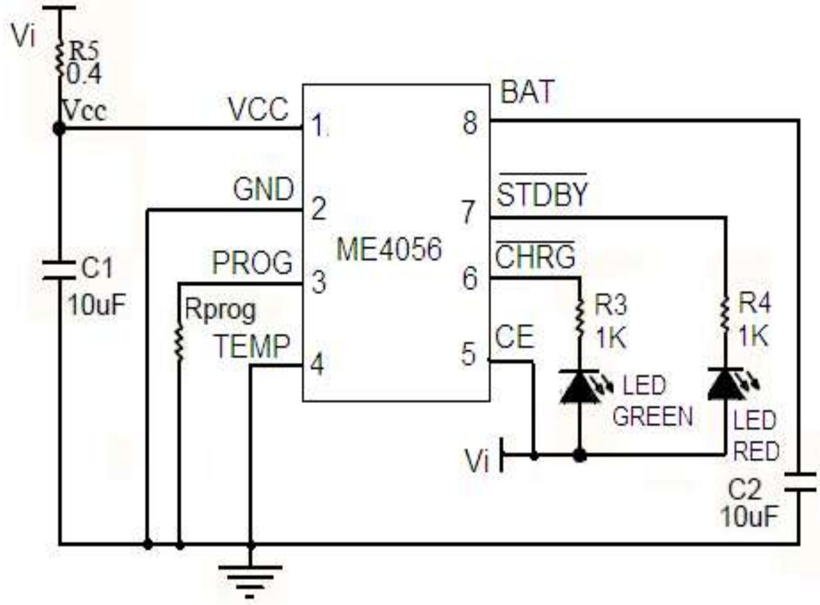
3. Suitable for the application which not need charge status indicator and battery's temperature detection.



4. Suitable for the application of USB power and the charge of wall adapter



5. Add a resistor for power dissipation, Red LED for charge status, green LED for charge terminate state



Absolute Maximum Ratings

Parameter	Rating	Unit
Input supply voltage : V_{CC}	-0.3～8	V
PROG pin voltage	-0.3～VCC+0.3	V
BAT pin voltage	-0.3～7	V
TEMP pin voltage	-0.3～10	V
$\overline{STDBY}$ pin voltage	-0.3～10	V
$\overline{CHRG}$ pin voltage	-0.3～10	V
CE pin voltage	-0.3～10	V
BAT pin current	1200	mA
PROG pin current	1200	μA
Maximum junction temperature	145	℃
Operating ambient temperature :T_{opa}	-40～85	℃
Storage temperature :T_{str}	-65～125	℃
Soldering temperature and time	+260（Recommended 10S）	℃

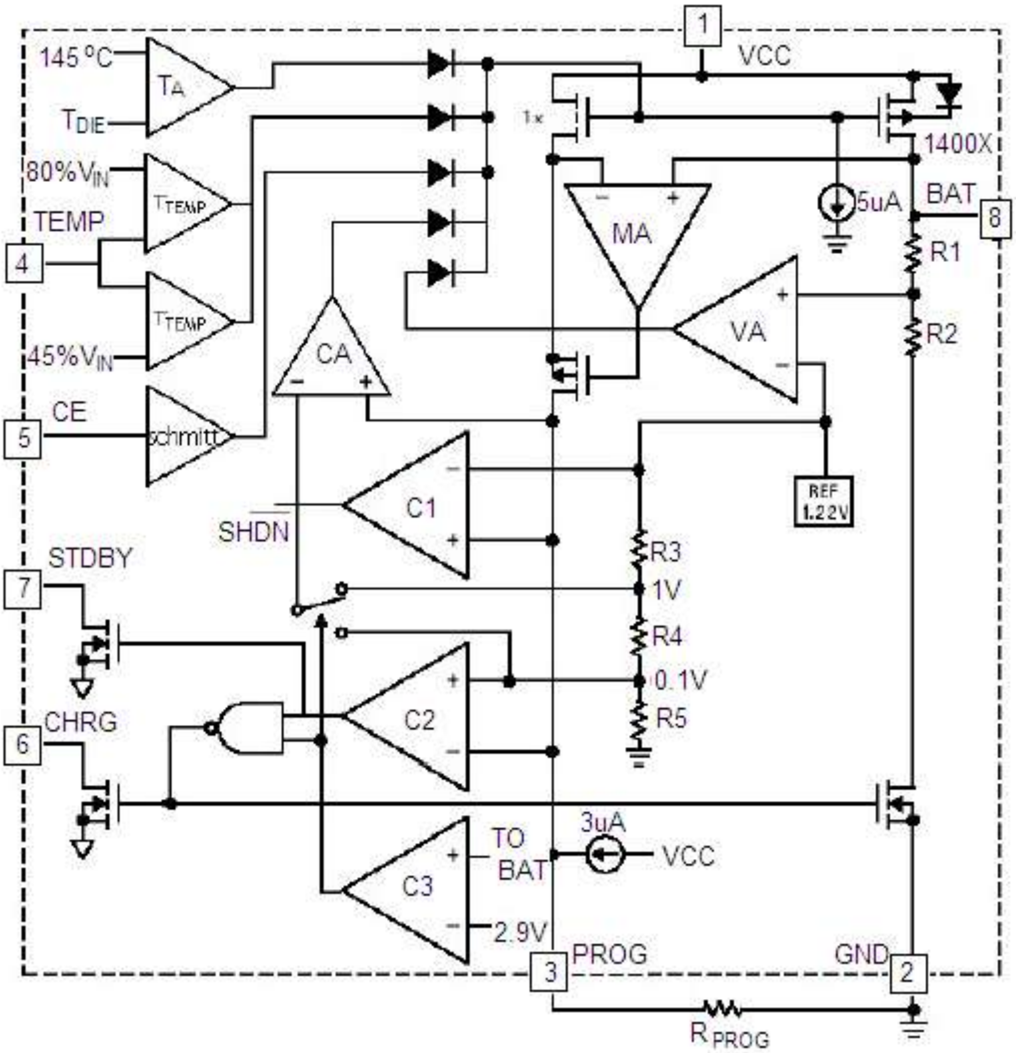
Caution: The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.

Electrical Characteristics

Symbol	Parameter	Condition	Min	Typ.	Max	Unit
V_{CC}	Input supply voltage	●	4.0	5.0	8.0	V
I_{CC} -I_{BAT}	static current	●Charge mode, R_{PROG}=1.4K	-	150	500	μA
		●Standby mode(charge end)	-	55	100	μA
		●Shutdown mode（R_{PROG} not connected, V_{CC}<V_{BAT}, or V_{CC}<V_{UV}）	-	55	100	μA
V_{FLOAL}	Regulated output voltage	0℃≤T_A≤85℃ I_{BAT}=40mA	4.137	4.2	4.263	V
I_{BAT}	BAT pin current (The condition of current mode is V_{BAT}=3.9V)	●R_{PROG}=2.8K, current mode	450	500	550	mA
		●R_{PROG}=1.4K,current mode	950	1000	1050	mA
		●Standby mode: V_{BAT}=4.2V	0	-2.5	-6	μA
		Shutdown mode, R_{PROG} not connected	-	±1	±2	μA
		Sleep mode, V_{CC}=0V	-	-1	-2	μA
I_{TRIKL}	Trickle charge current	●V_{BAT}<V_{TRIKL}, R_{PROG}=1.4K	120	130	140	mA
V_{TRIKL}	Trickle charge threshold voltage	R_{PROG}=1.4K, V_{BAT} rising	2.8	2.9	3.0	V
V_{TRHYS}	Trickle voltage hysteresis voltage	R_{PROG}=1.4K	150	200	250	mV
V_{UV}	V_{CC} under voltage lockout threshold	● V_{CC} from low to high	3.5	3.7	3.9	V
V_{UVHYS}	V_{CC} under voltage lockout hysteresis	●	150	200	300	mV
V_{ASD}	V_{CC}-V_{BAT} lockout threshold voltage	V_{CC} from low to high	100	140	180	mV
		V_{CC} from high to low	50	80	110	
I_{TERM}	C/10 termination current threshold	●R_{PROG}=2.8K	60	70	80	mA
		●R_{PROG}=1.4K	120	130	140	
V_{PROG}	PROG pin voltage	●R_{PROG}=1.4K，current mode	0.9	1.0	1.1	V
V_{CHRG}	$\overline{CHRG}$ Pin output low voltage	$I_{\overline{CHRG}}$ =5mA	-	0.3	0.6	V
V_{STDBY}	$\overline{STDBY}$ Pin output low voltage	$I_{\overline{STDBY}}$ =5mA	-	0.3	0.6	V
V_{TEMP-H}	The voltage at TEMP increase		-	80	83	%V_{CC}
V_{TEMP-L}	The voltage at TEMP decrease		42	45	-	%V_{CC}
ΔV_{RECHRG}	Recharge battery threshold voltage	V_{FLOAT} -V_{RECHRG}	120	180	240	mV
T_{LIM}	Thermal protection temperature		-	145	-	℃
R_{ON}	The resistance of power FET "ON"（between V_{CC} and BAT）		-	650	-	mΩ
t_{SS}	Soft-start time	I_{BAT}=0 to I_{BAT}=1400V/R_{PROG}	-	20	-	μS
$t_{RECHARGE}$	Recharge comparator filter time	V_{BAT} from high to low	0.8	1.8	4	mS
t_{TERM}	Termination comparator filter time	I_{BAT} below I_{CHG}/10	0.8	1.8	4	mS
I_{PROG}	PROG pin pull-up current		-	2.0	-	μA

Note: The ● denotes specifications which apply over the full operating temperature rang, otherwise specifications are at T_A=25℃，V_{CC}=5V，unless otherwise specified.

Block Diagram



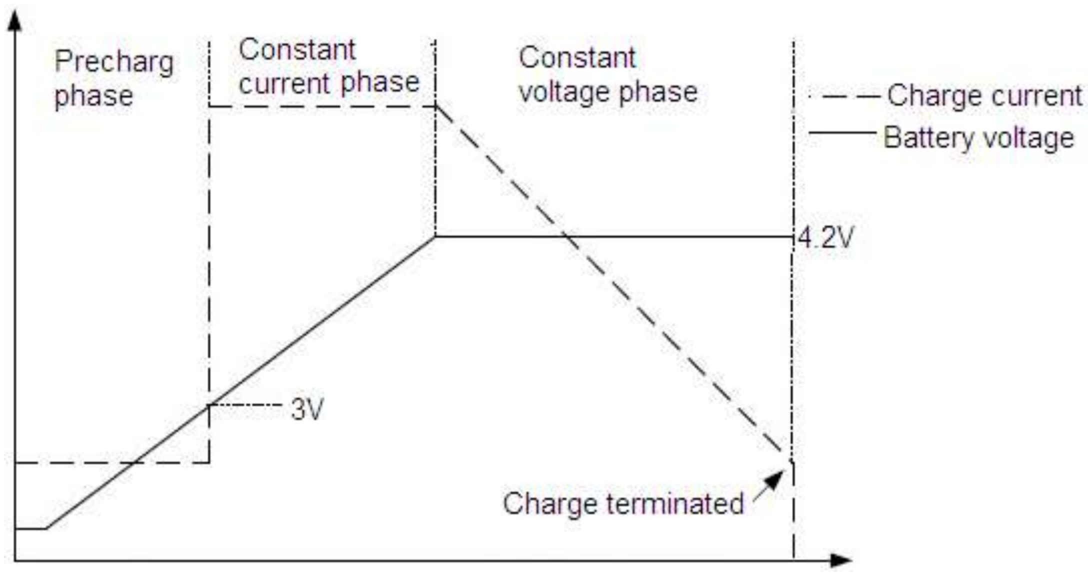
Description of the Principle

The ME4056 is a complete constant-current/constant-voltage linear charger for single cell lithium-ion batteries. Constant-current/constant-voltage to charger batter by internal MOSFET .It can deliver up to 1A of charge current .No blocking diode or external current sense resistor is required .ME4056 include two Open-Drain charge status Pins: Charge status indicator $\overline{CHRG}$ and battery failure status output $\overline{STDBY}$.

The internal thermal regulation circuit reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 145℃. This feature protects the ME4056 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 ME4056 or the external components. Another benefit of adopting thermal regulation is that charge current can be set according to typical, not worst-case, ambient temperatures for a given application with the assurance that the charger will automatically reduce the current in worst-case conditions.

The charge cycle begins when the voltage at the V_{CC} pin rises above the UVLO level, a current set resistor is connected from the PROG pin to ground, and the CE pin is pulled above the chip enable threshold. The $\overline{CHRG}$ pin outputs a logic low to indicate that the charge cycle is on going. At the beginning of the charge cycle, if the battery voltage is below 3V, the charge is in precharge mode to bring the cell voltage up to a safe level for charging. The charger goes into the fast charge constant-current mode once the voltage on the BAT pin rises above 3V. In constant current mode, the charge current is set by R_{PROG}. When the battery approaches the regulation voltage 4.2V, the charge current begins to decrease as the ME4056 enters the constant-voltage mode. When the current drops to charge termination threshold, the charge cycle is terminated, and $\overline{CHRG}$ pin assumes a high impedance state to indicate that the charge cycle is terminated and $\overline{STDBY}$ pin is pulled low. The charge termination threshold is 10% of the current in constant current mode. To restart the charge cycle, remove the input voltage and reapply it, or momentarily force CE pin to 0V. The charge cycle can also be automatically restarted if the BAT pin voltage falls below the recharge threshold. The on-chip reference voltage, error amplifier and the resistor divider provide regulation voltage with 1.5% accuracy which can meet the requirement of lithium-ion and lithium polymer batteries. When the input voltage is not present, or input voltage is below V_{BAT}, the charger goes into a sleep mode, dropping battery drain current to less than 3uA. This greatly reduces the current drain on the battery and increases the standby time. The charger can be shutdown by forcing the CE pin to GND.

The charging profile is shown in the following figure:



Programming charge current

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

$$R_{PROG} = \frac{1400}{I_{BAT}} \quad (\text{error} \pm 10\%)$$

In application, according the charge current to determine R_{PROG}, the relation between R_{PROG} and charge current can reference the following chart:：

R_{PROG} (K)	I_{BAT} (mA)
30	47
24	60
12	120
6	230
5	280
4	385
3	470
2	700
1.4	1000

Charge termination

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 for longer than t_{TEMP} (typically 1.8mS), Charging is terminated. The charge current is latched off and the ME4056 enters standby mode, where the input supply current drops to 55uA (Note:C/10 termination is disabled in trickle charging and thermal limiting modes).

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 1.8mS filter time (t_{TEMP}) 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 ME4056 terminated 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.

The ME4056 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.

Charge status indicator ($\overline{CHRG}$)

ME4056 has two open-drain status indicator output $\overline{CHRG}$ and $\overline{STDBY}$.$\overline{CHRG}$ is pull-down when the ME4056 in a charge cycle. In other status $\overline{CHRG}$ in high impedance. $\overline{CHRG}$ and $\overline{STDBY}$ are all in high impedance when the battery out of the normal temperature.

Represent in failure state, when TEMP pin in typical connecting, or the charger with no battery: red LED and green LED all don't light. The battery temperature sense function is disabled by connecting TEMP pin to GND. If battery is not connected to charger, $\overline{CHRG}$ pin outputs a PWM level to indicate no battery. If BAT pin connects a 10μF capacitor, the frequency of $\overline{CHRG}$ flicker about 1-4S, If not use status indicator should set status indicator output connected to GND.

charger's status	Red led $\overline{CHRG}$	Green led $\overline{STDBY}$
Charging	light	dark
Battery in full state	dark	light
Undervoltage, battery's temperature is to high or too low, or not connect to battery(use TEMP)	dark	dark
BAT pin is connected to 10uF capacitor，No battery mode (TEMP=GND)	Green LED bright, Red LED flicker F=1-4 S	

Thermal limiting

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 140℃ . The feature protects the ME4056 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 ME4056. 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.

To prevent the damage caused by the very high or very low temperature done to the battery pack, the ME4056 continuously senses battery pack temperature by measuring the voltage at TEMP pin determined by the voltage divider circuit and the battery's internal NTC thermistor as shown in Figure 1.

The ME4056 compares the voltage at TEMP pin (V_{TEMP}) against its internal V_{LOW} and V_{HIGH} thresholds to determine if charging is allowed. In ME4056, V_{LOW} is fixed at (45%×Vcc), while V_{HIGH} is fixed at (80%×Vcc). If $V_{TEMP}<V_{LOW}$ or $V_{TEMP}>V_{HIGH}$ for 0.15 seconds, it indicates that the battery temperature is too high or too low and the charge cycle is suspended. When V_{TEMP} is between V_{LOW} and V_{HIGH} for more than 0.15S, the charge cycle resumes. The battery temperature sense function can be disabled by connecting TEMP pin to GND.

Selecting R1 and R2

The values of R1 and R2 in the application circuit can be determined according to the assumed temperature monitor range and thermistor's values. The Follows is an example: Assume temperature monitor range is $T_L \sim T_H$，（ $T_L < T_H$)；the thermistor in battery has negative temperature coefficient（NTC），R_{TL} is thermistor's resistance at T_L，

R_{TH} is the resistance at T_H，so $R_{TL} > R_{TH}$，then at temperature T_L, the voltage at TEMP pin is:

$$V_{TEMPH} = \frac{R2 \| R_{TH}}{R1 + R2 \| R_{TH}} \times VIN$$

At temperature TH, the voltage at TEMP pin is:

$$V_{TEMPL} = \frac{R2 \| R_{TL}}{R1 + R2 \| R_{TL}} \times VIN$$

We know $V_{TEMPL} = V_{HIGH} = K2 \times Vcc$ (K2=0.8)；$V_{TEMPH} = V_{LOW} = K1 \times Vcc$ (K1=0.45) Then we can have：

$$R1 = \frac{R_{TL} R_{TH}(K_2 - K_1)}{(R_{TL} - R_{TH}) K_1 K_2} \qquad R2 = \frac{R_{TL} R_{TH}(K_2 - K_1)}{R_{TL}(K_1 - K_1 K_2) - R_{TH}(K_2 - K_1 K_2)}$$

Likewise, for positive temperature coefficient thermistor in battery, we have $R_{TH} > R_{TL}$ and we can calculate:

$$R1 = \frac{R_{TL} R_{TH}(K_2 - K_1)}{(R_{TH} - R_{TL}) K_1 K_2} \qquad R2 = \frac{R_{TL} R_{TH}(K_2 - K_1)}{R_{TH}(K_1 - K_1K_2) - R_{TL}(K_2 - K_1K_2)}$$

We can conclude that temperature monitor range is independent of power supply voltage V_{CC} and it only depends on R1, R2, R_{TL} and R_{TH}: The values of R_{TH} and R_{TL} can be found in related battery handbook or deduced from testing data. In actual application, if only one terminal temperature is concerned (normally protecting overheating), there is no need to use R2 but R1. It becomes very simple to calculate R1 in this case.

UnderVoltage lockout (UVLO)

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 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.

Manual terminate

At any time of the cycle of charging will put the ME4056 into disable mode to pull CE pin to GND, or remove R_{PROG} （PROG pin is float）. This made the battery drain current to less than 2uA and reducing the supply current to 55uA. To restart the charge cycle, set CE pin in high level or connect a programming resistor.

If ME4056 in the undervoltage Lockout mode, the $\overline{CHRG}$ and $\overline{STDBY}$ are all in high impedance state, or V_{CC} is above BAT pin 100mV, or V_{CC} is too low.

Auto restart

Once charge is been terminated, ME4056 immediately use a 1.8ms filter time（ $t_{RECHARGE}$ ）on the termination comparator to constant monitor the voltage on BAT pin. If this voltage drops below the 4.05V recharge threshold (about between 80% and 90% of V_{CC}), another charge cycle begins. This ensured the battery maintained (or approach) to a charge full status and avoid the requirement of restarting the periodic charging cycle. In the recharge cycle, $\overline{CHRG}$ pin enters a pulled down status.

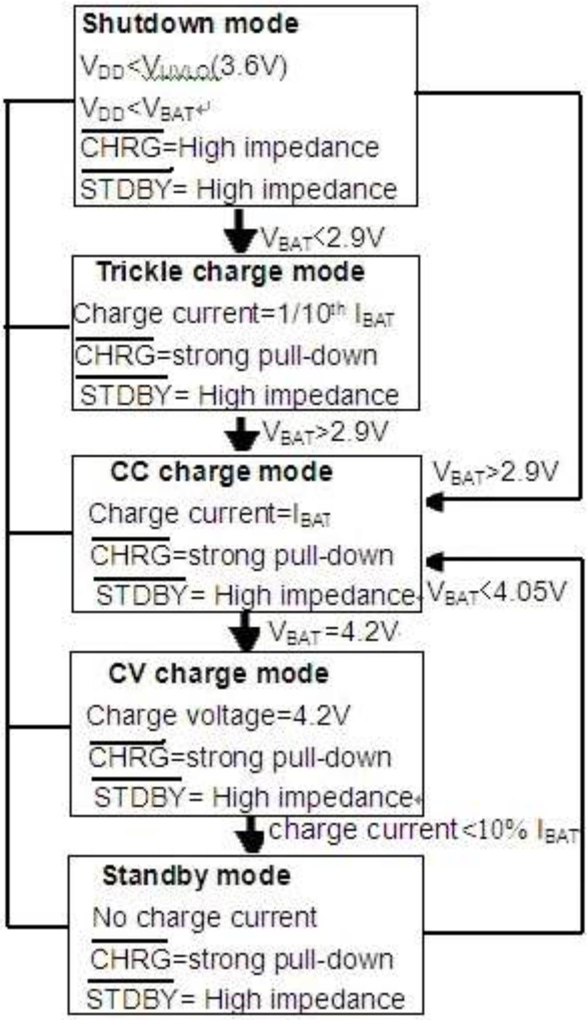
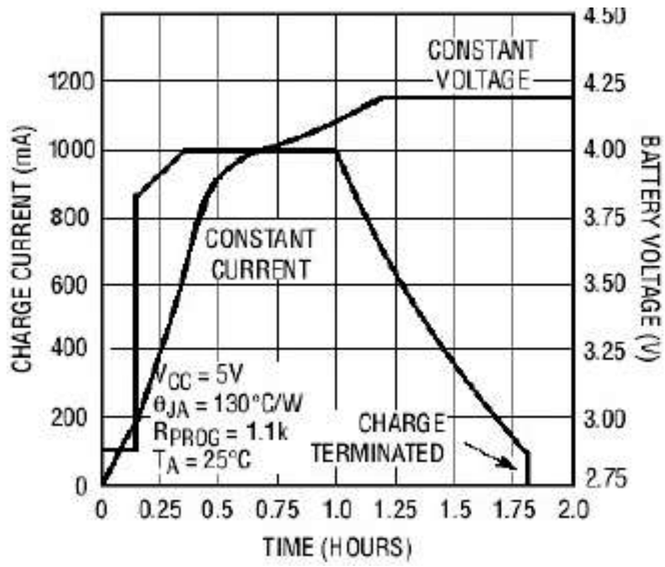


Fig.1 State diagram of a typical charge cycle



Typical charge cycle（1000mAh battery）

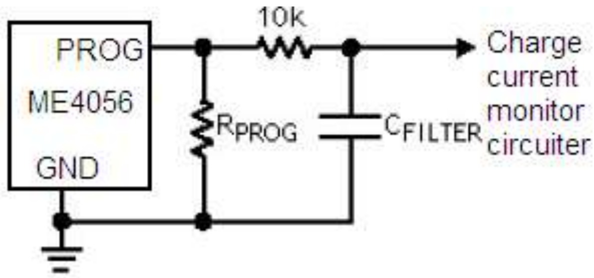


Fig.2 Isolating with capacitive load on PROG Pin

Stability Considerations

In constant-current mode, the PROG pin is in the feedback loop, not the battery. The constant-current mode stability is affected by the impedance at the PROG pin. With no additional capacitance on the PROG pin, the charger is stable with program resistor values as high as 20K. However, additional capacitance on this node reduces the maximum allowed program resistor. Therefore, if I_{PROG} pin is loaded with a capacitance C, the following equation should be used to calculate the maximum resistance value for R_{PROG}:

$$R_{PROG} \le \frac{1}{2\pi \bullet 10^5 \bullet C_{PROG}}$$

As user, may think charge current is important, not instantaneous current. For example, to run a low current mode switch power which parallel connected with battery, the average current from BAT pin usually importance to instantaneous current. In this case, In order to measure average charge current or isolate capacitive load from I_{PROG} pin, a simple RC filter can be used on PROG pin as shown in Figure 2. In order to ensure the stability add a 10K resistor between PROG pin and filter capacitor.

Power dissipation

The conditions that cause the ME4056 to reduce charge current through thermal feedback can be approximated by considering the power dissipated in the IC. Nearly all of this power dissipation is generated by the internal

MOSFET-this is calculated to be approximately: $P_D = (V_{CC} - V_{BAT}) \times I_{BAT}$

The approximate ambient temperature at which the thermal feedback begins to protect the IC is:

$$T_A = 145°C - P_D\theta_{JA}\ ;\ T_A = 145°C - (V_{CC} - V_{BAT}) \times I_{BAT} \times \theta_{JA}$$

For example: The ME4056 with 5V supply voltage through programmable provides full limiting current 800mA to a charge lithium-ion battery with 3.75V voltage. If θ_{JA} is 150℃/W (reference to PCB layout considerations), When ME4056 begins to decrease the charge current, the ambient temperature about:

$$T_A = 145°C - (5V - 3.75V) \times (800mA) \times 150°C/W$$

$$T_A = 145°C - 0.5W \times 150°C/W = 145°C - 75°C \qquad T_A = 65°C$$

ME4056 can work in the condition of the temperature is above 65℃, but the charge current will pull down to below 800mA. In a fixed ambient temperature, the charge current is calculated to be approximately :

$$I_{BAT} = \frac{145°C - T_A}{(V_{CC} - V_{BAT}) \bullet \theta_{JA}}$$

Just as Description of the Principle part talks about so, the current on PROG pin will reduce in proportion to the reduced charge current through thermal feedback. In ME4056 design applications don't need to considerate the worst case of thermal condition, this point is importance, because if the junction temperature up to 145℃ ,IC will auto reduce the power dissipation.

Thermal considerations

Because of the small size of the thin SOP8 package, it is important to use a good thermal PC board layout to maximize the available charge current. The thermal path for the heat generated by the IC is from the die to the copper lead frame, through the package leads, (especially the ground lead) to the PC board copper. The PC board copper is the heat sink. The footprint copper pads should be as wide as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient. Other heat sources on the board, not related to the charger, must also be considered when designing a PC board layout because they will affect overall temperature rise and the maximum charge current.

Add thermal regulation current

It will effective to decrease the power dissipation through reduce the voltage of both ends of the inner MOSFET. In the thermal regulation, this action of transporting current to battery will raise. One of the measure is through an external component(as a resistor or diode) to consume some power dissipation.

For example: The ME4056 with 5V supply voltage through programmable provides full limiting current 800mA to a charge lithium-ion battery with 3.75V voltage. If θ_{JA} is 125℃/W, so that at 25℃ ambient temperature, the charge current is calculated to be approximately :

$$I_{BAT} = \frac{145°C - 25°C}{(V_S - I_{BAT}R_{CC} - V_{BAT}) \bullet \theta_{JA}}$$

In order to increase the thermal regulation charge current , can decrease the power dissipation of the IC through reducing the voltage (as show fig.3) of both two ends of the resistor which connecting in series with a 5V AC adapter. With square equation to calculate I_{BAT} :

$$I_{BAT} = \frac{(V_S - V_{BAT} - \sqrt{(V_S - V_{BAT})^2 - \frac{4R_{CC}(145°C - T_A)}{\theta_{JA}}}}{2R_{CC}}$$

If R_{CC}=0.25Ω, V_S=5V, V_{BAT}=3.75V, T_A=25℃ and θ_{JA} =125℃/W, we can calculate the thermal regulation charge current: I_{BAT}=948mA. It means that in this structure it can output 800mA full limiting charge current at more high ambient temperature environment.

Although it can transport more energy and reduce the charge time in this application, but actually spread charge time, if ME4056 stay in undervoltage state, when V_{CC} becomes too low in voltage mode. Fig.4 shows how the voltage reduced with increase R_{CC} value in this circuit. This technique will act the best function when in order to maintain the minimize the dimension of the components and avoid voltage decreased to minimize R_{CC} .

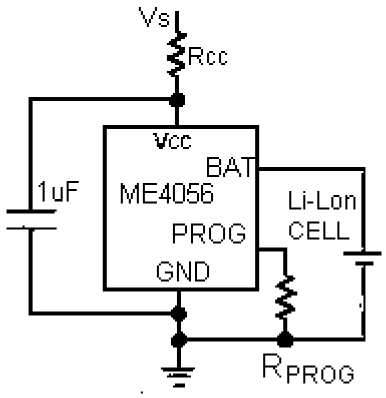


Fig.3:A circuit to maximum the thermal regulation charge current

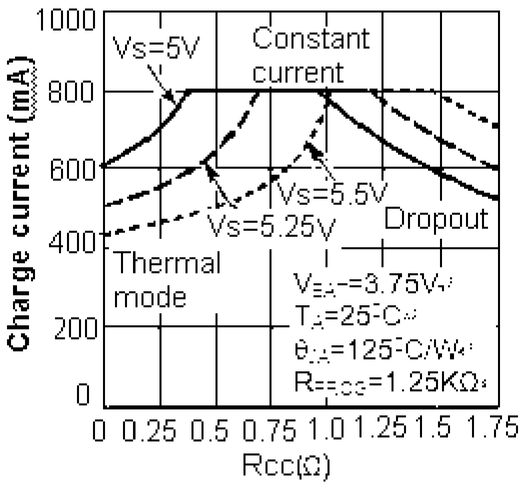


Fig.4:The relationship curve between charge current with R_{CC}

V_{CC} bypass capacitor

Many types of capacitors can be used for input bypassing, however, caution must be exercised when using multilayer ceramic capacitors. Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, high voltage transients can be generated under some start-up conditions, such as connecting the charger input to a live power source. Adding a 1.5Ωresistor in series with a ceramic capacitor will minimize start-up voltage transients.

Charging Current Soft Start

ME4056 includes a soft start circuit which used to maximize to reduce the surge current in the begging of charge cycle. When restart a new charge cycle, the charging current ramps up from 0 to the full charging current within 20μs. In the start process it can maximize to reduce the action which caused by surge current load.

USB and Wall Adapter Power

ME4056 allows charging from a USB port, a wall adapter can also be used to charge Li-Ion/Li-polymer batteries. Figure 5 shows an example of how to combine wall adapter and USB power inputs. A P-channel MOSFET, M1, is used to prevent back conducting into the USB port when a wall adapter is present and Schottky diode, D1, is used to prevent USB power loss through the 1kΩ pull-down resistor.

Generally, AC adaptor is able to provide bigger much current than the value of specific current limiting which is 500mA for USB port. So can rise charge current to 600mA with using a N-MOSFET (MN1) and an additional set resistor value as high as 10K.

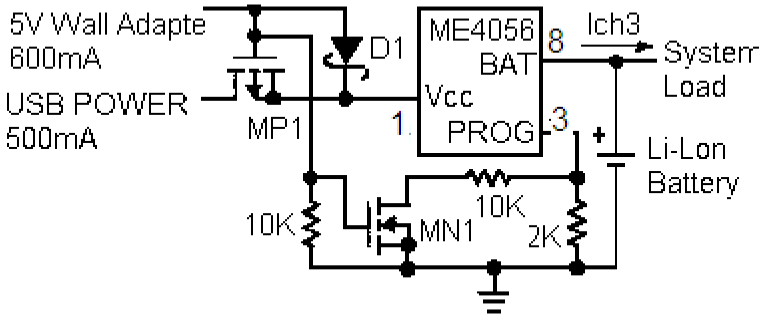


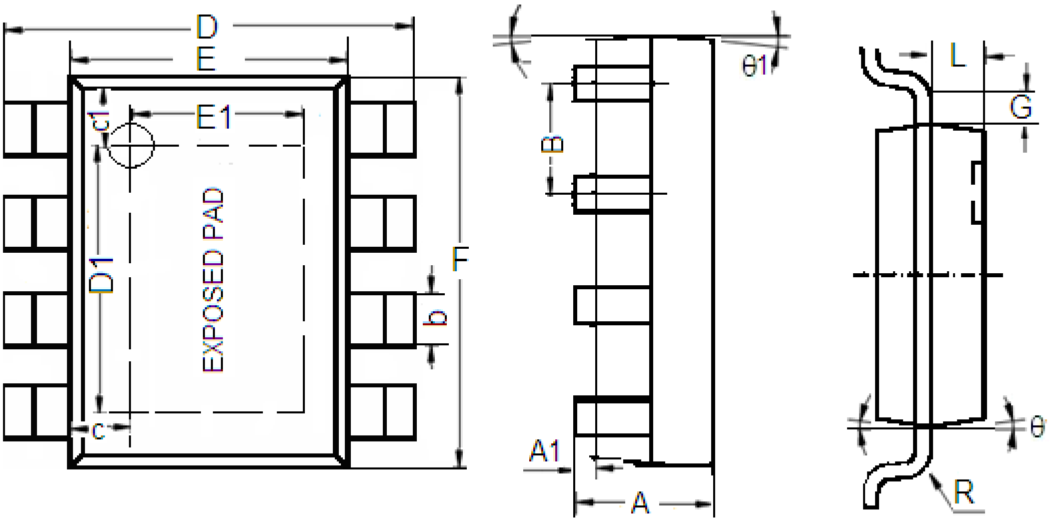
Fig.5: Combining Wall Adapter and USB Power

Board Layout Considerations

- R_{PROG} at PROG pin should be as close to ME4056 as possible, also the parasitic capacitance at PROG pin should be kept as small as possible.
- The capacitance at V_{CC} pin and BAT pin should be as close to ME4056 as possible.
- During charging, ME4056's temperature may be high, the NTC thermistor should be placed far enough to ME4056 so that the thermistor can reflect the battery's temperature correctly.
- It is very important to use a good thermal PC board layout to maximize charging current. The thermal path for the heat generated by the IC is from the die to the copper lead frame through the package lead (especially the ground lead) to the PC board copper, the PC board copper is the heat sink. The footprint copper pads should be as wide as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient. Feed through vias to inner or backside copper layers are also useful in improving the overall thermal performance of the charger. Other heat sources on the board, not related to the charger, must also be considered when designing a PC board layout because they will affect overall temperature rise and the maximum charge current.
- The ability to deliver maximum charge current under all conditions require that the exposed metal pad on the back side of the ME4056 package be soldered to the PC board ground. Failure to make the thermal contact between the exposed pad on the backside of the package and the copper board will result in larger thermal resistance.

Packaging Information:

Packaging Type: SOP8-PP



Character	Dimension (mm)		Dimension (Inches)	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.1	0.3	0.004	0.012
B	1.27(Typ.)		0.05(Typ.)	
b	0.330	0.510	0.013	0.020
c	0.9(Typ.)		0.035(Typ.)	
c1	1.0(Typ.)		0.039(Typ.)	
D	5.8	6.2	0.228	0.244
D1	3.202	3.402	0.126	0.134
E	3.800	4.000	0.150	0.157
E1	2.313	2.513	0.091	0.099
F	4.7	5.1	0.185	0.201
L	0.675	0.725	0.027	0.029
G	0.32(Typ.)		0.013(Typ.)	
R	0.15(Typ.)		0.006(Typ.)	
θ1	7°		7°	
θ	8°		8°	