

## Standalone Linear Li-Ion Battery Charger With Thermal Regulation in ThinSOT

### Description

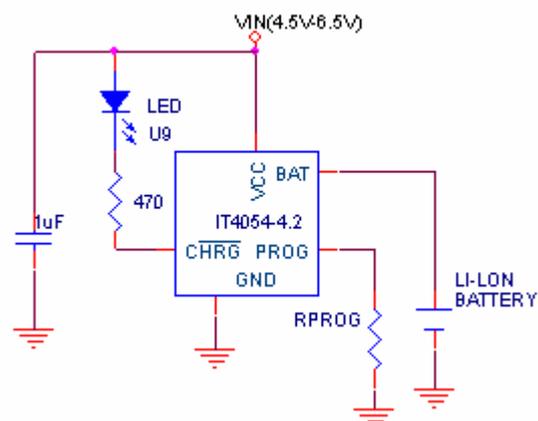
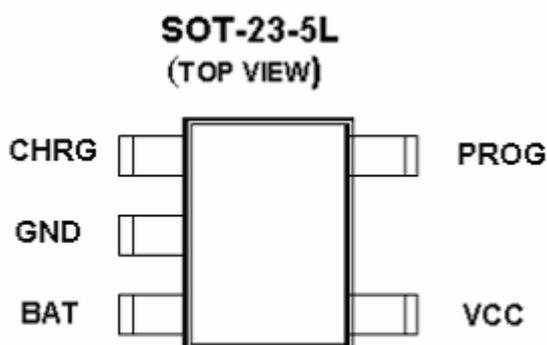
IT4054 is a complete constant-current & Constant voltage linear charge for single cell Lithium-ion and Lithium-Polymer batteries. Its Make IT4054 ideally suited for portable Applications. Furthermore. The IT4054 is Specifically designed to work within USB Power sprcification. At the same time, IT4054 Can also be used in the standalone lithium - Ion And Lithium-polymer battery charger. No external sense resistor is needed, and No Blocking diode is required due to the Internal MOSFET architecture. Thermal feedback Regulates the charge current to limit the dieTemperature 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 IT4054 automatically thminates 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 IT4054 automatically enters a low current stage,dropping the battery drain current to less than 2uA The IT4054 can be put into shutdown mode. Reducing the supply current to 25 uA. Other features include charge current monitor, Undervoltage lockout, automatic recharge and a status Pin to indicate charge termination and the presence of An input voltage. Other features include charge current monitor,undervoltage Lockout,automatic recharge and a status pin to indicate Charge termination and the presenceof an input voltage

### Features

- Programmable Charge Current Up to 800mA.
- No MOSFET,Sense Resistor or Blocking Diode Required.
- Constant-Current/Constant-Voltage Operation with Thermal Protection to Maximize Charge Rate without Risk of Overheating.
- Charges Single Cell Li-Ion Batteries Directly from USB Port.
- Preset 4.2V Charge Voltage with  $\pm 1\%$  Accuracy.
- 25uA Supply Current in Shutdown
- 2.9V Trickle Charge Threshold
- Available Without Trickle Charge
- Soft-Start Limits Inrush Current
- Available in 5-Lead SOT-23 Package

### Application

- Cellular Telephones. PDA's,MP3 Players.
- Charging Docks and Cradles
- Bluetooth Applications



## Absolute Maximum Rating

Parameter	Symbol	Value	Units
Input supply Voltage	Vcc	8	V
PROG Voltage	VPROG	VCC+0.3	V
BAT Voltage	VBAT	7	V
CHRG Voltage	VCHRG	10	V
BAT Short-Circuit Duration		Continuous	
BAT Pin Current	IBAT	800	mA
PROG Pin Current	I <sub>PROG</sub>	800	μA
Maximum Junction Temperature	T <sub>J</sub>	125	°C
Storage Temperature	T <sub>S</sub>	-65 to +125	°C
Lead Temperature (Soldering, 10 sec)		300	°C

## Operating Rating

Parameter	Symbol	Value	Units
Supply Input Voltage	V <sub>IN</sub>	-0.3 to + 8	V
Junction Temperature	T <sub>J</sub>	-40 to +85	°C

## Electrical Characteristics

V<sub>IN</sub>=5V; T<sub>J</sub>=25°C; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
VCC	Input Supply Voltage		4.25		6	V
ICC	Input Supply Current	Charge Mode, RPROG=10K		190		μA
		Standby Mode (Charge Terminated)		85		μA
		Shutdown Mode (RPROG Not Connected, VCC < VBAT, or VCC < VUV)		12		μA
VFLOAT	Regulated Output (Float) Voltage	0°C ≤ T <sub>J</sub> ≤ 85°C, IBAT=40mA		4.2		V
IBAT	BAT Pin Current	RPROG=10K, Current Mode		110		mA
		RPROG=2K, Current Mode		500		mA
		Standby Mode, VBAT=4.2V		4		μA
		Shutdown Mode (RPROG Not Connected)		±1		μA
		Sleep Mode, Vcc=0V		±1		μA
ITRIKL	Trickle Charge current	VBAT < VTRIKL, RPROG=10K		12		mA
VTRIKL	Trickle Charge Threshold Voltage	RPROG=10K, VBAT Rising		2.9		V

## Electrical Characteristics(Continued)

VIN=5V, TJ=25°C, unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
VUV	Vcc Undervoltage Lockout Threshold	From Vcc Low to High		3.4		V
VUVHYS	Vcc Undervoltage Lockout Hysteresis			170		mV
VMSD	Manual Shutdown Threshold Voltage	PROG Pin Rising		1.25		V
		PROG Pin Falling		1.2		V
VASD	Vcc-VBAT Lockout Threshold Voltage	Vcc from Low to High		100		mV
		Vcc from High to Low		30		mV
ITERM	C/10 Termination Current Threshold	RPROG=10K		0.1		mA/mA
		RPROG=2K		0.1		mA/mA
VPROG	PROG Pin Voltage	RPROG=10K,Current Mode		1.03		V
ICHRG	CHRG Pin Weak Pull-Down Current	VCHRG=5V		20		μA
VCHRG	CHRG Pin Output Low Voltage	ICHRG=5mA		0.35		V
△ VRGCHRG	Recharge Battery Threshold Voltage	VFLOAT-VRECHRG		100		mV
TLIM	Thermal Protection Temperature			120		°C
tss	Soft-Start Time	IBAT=0 to 1000V/RRPOG		100		μs
tRECHARGE	Recharge Comparator Filter Time	VBAT High to Low		2		ms
tTERM	Termination Comparator Filter Time	IBAT Falling Below ICHG/10		1000		μs
IPROG	PROG Pin Pull-up Current			1		μA

### Pin Functions

**CHRG(Pin):** Open-Drain Charge Status Output. When the battery is charging, the CHRG pin is pulled low by an internal N-channel MOSFET. When the charge cycle is completed, a weak pull-down of approximately 20 μA is connected to the CHRG pin. Indicating an “AC present” condition. When the IT4054 detects an undervoltage lockout condition. CHRG is forced high impedance.

**BAT(Pin 2):** Ground.

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

**Vcc (Pin 4):** Positive Input Supply Voltage. Provides Power to the charger. Vcc can range from 4.25Vt to 6.5V And should be bypassed with at least a 1μF capacitor When Vcc drops to within 30mV of the BAT pin voltage ,the IT4054 enters shutdown mode, dropping I<sub>BAT</sub> to less than 2μA.

**PROG(Pin 5):** Charge Current Proguam, Charge Current Monitor and Shutdown Pin. The charge current is programmed by connecting a 1% resistor, R<sub>PROG</sub>, to ground. When charging in constant-current mode, this pin servos to 1V. In all modes, the voltage on this pin can be used to measure the charge current using the follwing formula:

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

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

## OPERATION

The IT4054 is a single cell lithium-ion battery charger Using a constant-current/constant-voltage algorithm. It can deliver up to 800mA of charge current (using a Good thermal PCB layout)with a final float voltage accuracy of  $\pm 1\%$ .The IT4054includes an internal P-channel power MOSFET and thermal regulation circuitry. No blocking diode or external current sense resistor is required , thus , the basic charger circuit requires only two external com-ponents.Furthermore the IT4054 is capable of operat-ing froma USB source.

### Normal Charge Cycle

A charge cycle begins when the voltage at the Vcc pin rises above the UVLO threshold level and a 1%program resistor is connected from the PROG pin to ground or when a battery is connected to the charge output. If the BAT pin is less than 2.9V,the charger enters trickle charge mode.In this mode. The IT 4054 supplies approximately 1/10 the progranned charge current to bring the battery volt-age up to a safe level for full current charging, (Note: The IT4054X does not include this trickle charge feature) When the BAT pin voltage rises above 2.9V,the charger enters constant-current mode,where the programmed charge current is supplied to the battery .When the BAT pin approaches the final float voltage(4.2V),the IT4054 enters constant-voltage mode and the charge current begins to decrease. When the charge current drops to 1/10 of the programmed value,the charge cycle ends.

### Programming Charge Current

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

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

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

the following equation:

$$I_{BAT} = V_{PROG} / R_{PROG} \cdot 1000$$

### 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  $100mV^1$  for longer than  $t_{TERM}$  (typically 1ms),charging is terminated,The charge current is latched off and the IT 4054 enters standby mode. Where the input supply current drops to  $200\mu A$ . (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 1mS filter time( $t_{TERM}$ ) On the termination comparator ensures that transient loads of this nature do not result in premature charge cycle termi-nation.Once the average charge current drops below 1/10th the programmed value.the IT4054 terminates the charge cycle and ceases to provide any current through the BAT pin .In this state,all loads on the BAT pin must be supplied by the battery.

The IT4054 constantly monitors the BAT pin voltage in standby mode.If this voltage drops below the 4.05V recharge threshold ( $B_{RECHRG}$ ), another charge cycle begins and current is once again supplied to the battery.To manually restart a charge cycle when in standby mode.the the Input voltage must be removed and reapplied, or the charge 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)

The charge status output has three different states:strong pull-down ( $\sim 10 mA$  ),weak pull-down ( $\sim 20\mu A$ )and high impedance. The strong pull-down state indicates that the IT4054 is in a charge cycle. Once the charge cycle has terminated,the pin state is determined by undervoltage.

## Operation

Lockout conditions. A weak pull-down indicates that  $V_{CC}$  Meets the UVLO conditions and the IT4054 is ready to Charge. High impedance indicates that the IT4054 is in Undervoltage lockout mode: either  $V_{CC}$  is less than 100 mV above the BAT pin voltage or insufficient voltage is applied to the  $V_{CC}$  pin. A microprocessor can be used to distinguish between these three states—this method is discussed in the Applications Information section.

### 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 120°C. This feature protects the IT4054 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 IT4054. The charge current can be set according to typical (not worst-case) ambient temperature with the assurance that the charger will automatically reduce the current in worst-case conditions. ThinSOT power considerations are discussed further in The Applications Information section.

### Undervoltage Lockout(UVLO)

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

### Manual Shutdown

At any point in the charge cycle, the IT4054 can be put into shutdown mode by removing  $R_{RPOG}$  thus floating the PROG pin. This reduces the battery drain current to less than 2 $\mu$ A and the supply current to less than 50 $\mu$ A. A new Charge cycle can be initiated by reconnecting the program resistor.

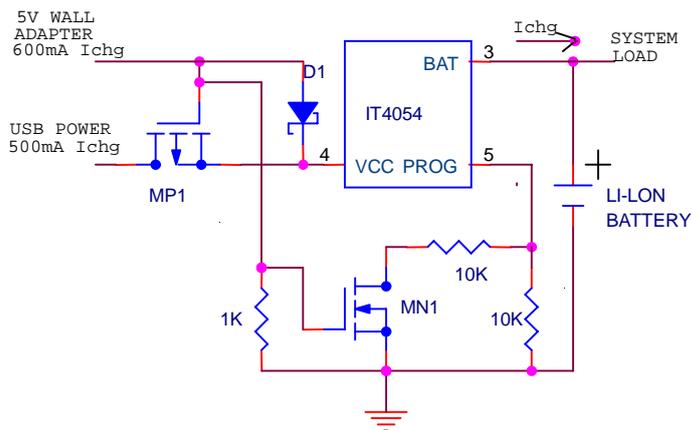
In manual shutdown, the CHRG pin is in a weak pull-down state as long  $V_{CC}$  is high enough to exceed the UVLO conditions. The CHRG pin is in a high impedance state if the IT4054 is in undervoltage lockout mode: either  $V_{CC}$  is within 100mV of the BAT pin voltage or insufficient voltage is applied to  $V_{CC}$  pin.

### Automatic Recharge

Once the charge cycle is terminated, the IT4054 continuously monitors the voltage on the BAT pin using a comparator with a 2ms filter time ( $t_{RECHARGE}$ ). A charge cycle restarts when the battery voltage falls below 4.05V (which corresponds to approximately 80% to 90% battery capacity). This ensures that the battery is kept at or near a fully charge condition and eliminates the need for periodic charge cycle initiations. CHRG output enters a strong pull-down state during recharge cycle.

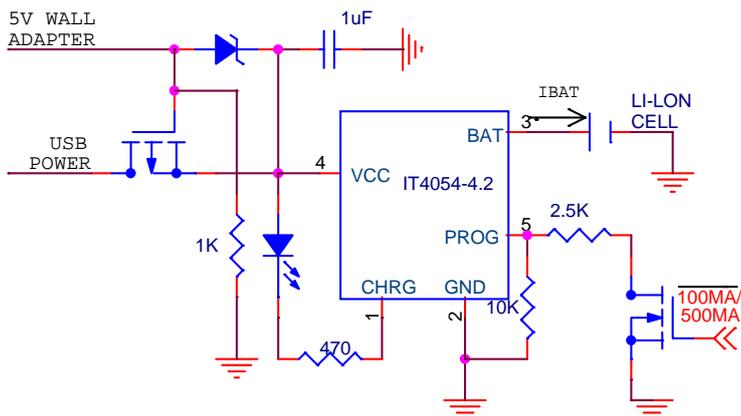
**APPLICATION INFORMATION**

USB and Wall Adapter Power The IT 4054 allows charging from both a wall Adapter and a USB port, Figure 7 shows an example Of how to combine wall adapter and USB Of how to combine wall adapter and USB power inputs. A P-channel MOSFET, MP1, is used to prevent back conducting Into the USB port when a wall adapter is present and a schottky Diode, D1, is used to prevent USB power loss through the 1k Pull-down resistor Typically a wall adapter can supply more current than the 500Ma-Limited USB port. Therefore an-N-channel MOSFET, MN1, and an extra 10k program resistor are used to Increase the charge current to 600mA when the wall Adapter is present.

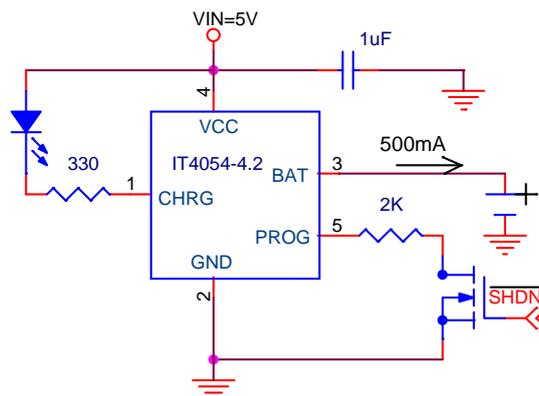


**TYPICAL APPLICATION**

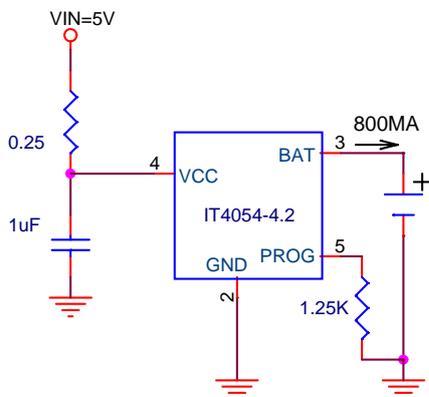
**USB/Wall Adapter Power Li-Ion Charger**



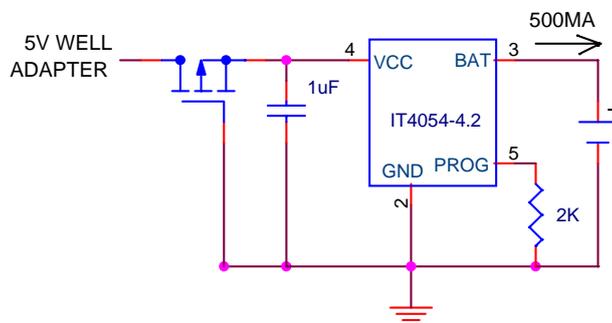
**Full Featured Single Cell Li-Ion Charger**



**800mA Li-Ion Charger with External power Dissipation**



**Basic Li-Ion Charger with Reverse Polarity input Protection**



## PACKAGE DESCRIPTION

S5 Package  
5-Lead Plastic TSOT-23  
Reference IT DWG 05-08-1635

