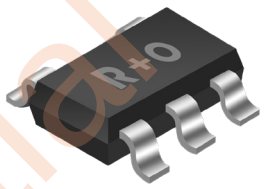
600mA Standalone Linear Li-Ion Battery Charger

Features

- Programmable Charge Current Up to 600mA
- No MOSFET, Sense Resistor or Blocking Diode Required
- Constant-Current/Constant-Voltage Operation with Thermal Regulation to Maximize Charge Rate Without Risk of Overheating.
- 4.2V Charge Voltage with ± 1% Accuracy
- Charge Current Monitor Output for Gas Gauging
- Automatic Recharge
- 2.9V Trickle Charge Threshold
- Anti-reverse Connection Protector

Charge Current
600mA(Max.)
Charge Voltage
4.2V ± 1%

SOT-23-5L



Applications

- Cellular Telephones, PDAs, MP3 Players
- Digital Still Cameras
- Charging Docks and Cradles
- Bluetooth Applications

General Description

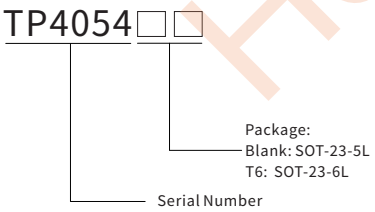
The TP4054 is a complete constant-current/constant- voltage linear charger for single cell lithium-ion batteries. Its SOT23-5 package and low external component count make the TP4054 ideally suited for portable applications. Furthermore, the TP4054 is specifically designed to work within USB power specifications.

No external sense resistor is needed, and no blocking diode is required due to the internal MOSFET architecture. Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature. The charge voltage is fixed at 4.2V, and the charge current can be programmed externally with a single resistor. The TP4054 automatically terminates the charge cycle when the charge current drops to 1.0/10th the programmed value after the final float voltage is reached.

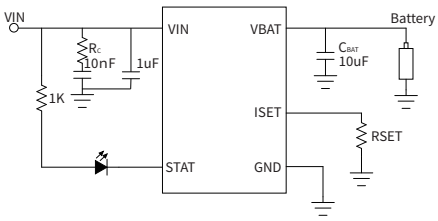
When the input supply (wall adapter or USB supply) is removed, the TP4054 automatically enters a low current state, dropping the battery drain current to less than 0.5μA.

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.

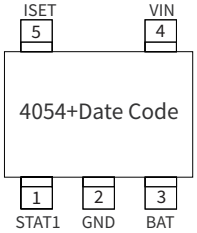
Part Numbering



Typical Application Circuit



Pin Configuration & Marking(Top View)



SOT-23-5L

Pin Description

Pin Number	Pin Name	Description
SOT23-5		
1	STAT1	Open-Drain Charge Status Output. When the battery is charging, the STAT pin is pulled low by an internal N-channel MOSFET. When the charge cycle is completed, the pin is pulled High.
2	GND	Ground.
3	BAT	Charge Current Output. Provides charge current to the battery and regulates the final float voltage to 4.2V.
4	VIN	Positive Input Supply Voltage.
5	ISET	Charge Current Program and Charge Current Monitor Pin. The charge current is programmed by connecting a 1% resistor, R_{ISET}, to ground. When charging in constant-current mode, this pin servos to 1V. In all modes, the voltage on this pin can be used to measure the charge current using the following formula: $I_{BAT} = 1000/R_{ISET}$.

Ordering Information & Marking

Order Number	Package	Marking Code	Unit Weight(g)	Tube(pcs)	Box(pcs)	Carton(pcs)	Delivery Mode	MSL
TP4054	SOT-23-5L	4054+DC	0.0798	3000	45000	180000	7"	2

Functional Block Diagram

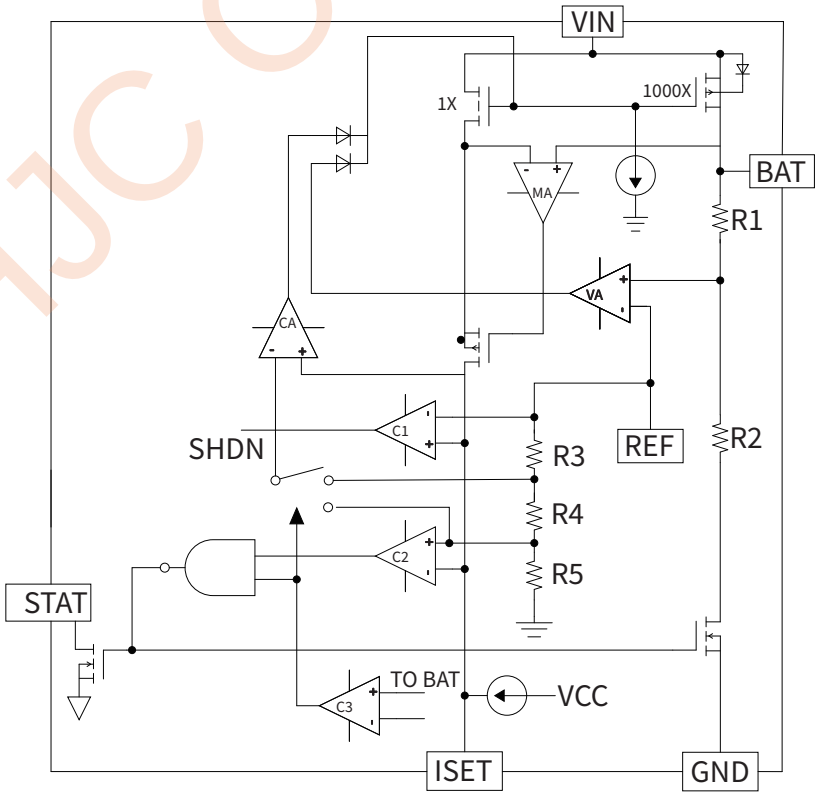


Figure 1.Internal Block Diagram

Absolute Maximum Ratings (T_A = 25°C Unless otherwise specified)

Parameter	Symbol	Value	Unit
Maximum Supply Voltage	V_{CC}	-0.3 to 7.5	V
BAT Pin Current	I_{BAT}	600	mA
ISET Pin Current	I_{SET}	600	μA
Other Pin to GND	V_{BAT}, V_{ISET}, $V_{STAT1,2}$	-0.3 to 6	V
BAT Short-Circuit Duration	--	Continuous	V
Maximum Junction Temperature	T_J	125	°C
Operating Ambient Temperature Range	T_{OP}	-40 to 85	°C
Storage Temperature Range	T_{STG}	-65 to 125	°C
Maximum Power Dissipation (SOT23-5, PD)	P_D	0.45	W
Thermal Resistance (SJA)	R_{thJA}	250	°C /W
Electrostatic Discharge Voltage	V_{ESD}	2000	V

Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

Electrical Characteristics (T_A = 25°C , V_{IN} = 5V, unless otherwise specified.)

Parameter Name	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Adapter/USB Voltage Range	V_{IN}	--	4.5	5	6.5	V
Input Supply Current	I_{IN}	Standby Mode (Charge Terminated)	--	50	--	μA
Regulated Output (Float) Voltage	V_{FLOAT}	I_{BAT} = 40mA	4.158	4.2	4.242	V
BAT Pin Current	I_{BAT}	R_{ISET} = 10K, Current Mode	--	100	--	mA
		R_{ISET} = 2K, Current Mode	--	500	--	
		Standby Mode, V_{BAT} = 4.2V Sleep Mode, V_{IN} = 0V	--	0.3	0.5	μA
Trickle Charge Threshold Voltage	V_{TRIKL}	R_{ISET} = 10k, V_{BAT} Rising	--	3	--	V
Trickle Charge Hysteresis Voltage	V_{TRHYS}	R_{ISET} = 10K	--	150	--	mV
Trickle charge current	I_{TRIKL}	V_{BAT} < V_{TRIKL}, R_{ISET} = 10K	--	50	--	mA
		V_{BAT} < V_{TRIKL}, R_{ISET}= 2K	--	200	--	
V_{IN} Undervoltage Lockout Threshold	V_{UV}	From VIN Low to High	3.5	3.7	3.9	V
V_{IN} Undervoltage Lockout Hysteresis	V_{UVHYS}	--	--	200	--	mV
V_{IN}–VBAT Lockout Threshold Voltage	V_{ASD}	--	--	160	200	mV
C/10 Termination Current Threshold	I_{TERM}	--	--	15	--	% I_{BAT}
ISET Pin Voltage	V_{ISET}	R_{ISET} = 10K, Charge Mode	--	1	--	V
STAT1/STAT2 Pin Output Low Voltage	V_{STAT}	I_{STAT} = 5mA	--	--	0.5	V
STAT1/2 Pin Weak Pull-Down Current	I_{STAT}	I_{CHRG} = 5V	-	--	5	μA
Recharge Battery Threshold Voltage	ΔV_{RECHRG}	V_{FLOAT} - V_{RECHRG}	--	200	--	mV

Application Information

The TP4054 is a single cell lithium-ion battery charger using a constant-current/constant-voltage algorithm. It can deliver up to 600mA of charge current (using a good thermal PCB layout) with a final float voltage accuracy of ± 1%. The TP4054 includes an internal P-Channel power MOSFET and thermal regulation circuitry. No blocking diode or external current sense resistor is required. It is also possible to use an USB port as power supply voltage.

Normal Charge Cycle

A charge cycle begins when the voltage at the V_{IN} pin rises above the UVLO threshold level and a 1% program resistor is connected from the ISET pin to ground or when a battery is connected to the charger output. If the BAT pin is less than 2.9V, the charger enters trickle charge mode.

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 TP4054 enters constant-voltage mode and the charge current begins to decrease. When the charge current drops to 1.5/10 of the programmed value the charge cycle ends.

Programming Charge

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

$$R_{ISET} = 1000 \div I_{BAT},$$

$$I_{BAT} = 1000 \div R_{ISET}$$

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

$$I_{BAT} = V_{ISET} \div R_{ISET} \times 1000$$

Charge Status Indicator (STAT1, 2)

The charge status output has two different states: strong pull-down (~5mA) and high impedance. The strong pull-down state indicates that the TP4054 is in a charge cycle. High impedance indicates that the charge cycle complete or the TP4054 is in under voltage lockout mode: either V_{IN} is less than 150mV above the BAT pin voltage or insufficient voltage is applied to the V_{IN} pin. A microprocessor can be used to distinguish between these two states.

Charge Stage	STAT Status
Charging	Low
Charge Complete	High

Charge Termination

A charge cycle is terminated when the charge current falls to 1.5/10th the programmed value after the final float voltage is reached. This condition is detected by using an internal, filtered comparator to monitor the ISET pin. When the ISET pin voltage falls below 100mV for longer than T_{TERM} (typically 1ms), charging is terminated. The charge current is latched off and the TP4054 enters standby mode, where the input supply current drops to 50μA. When charging, transient loads on the BAT pin can cause the ISET pin to fall below 150mV for short periods of time before the DC charge current has dropped to 1.5/10th the programmed value. The 1ms filter time (T_{TERM}) on the termination comparator ensures that transient loads of this nature do not result in premature charge cycle termination. Once the average charge current drops below 1.5/10th the programmed value, the TP4054 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 TP4054 constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the 4.0V 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.

Thermal Limit

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 125 degree. This feature protects the TP4054 from excessive temperature and allows the user to push the of the power handling capability of a given circuit board without risk of damaging the TP4054. 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.

Automatic Recharge

Once the charge cycle is terminated, the TP4054 continuously monitors the voltage on the BAT pin using a comparator with a 2ms

Automatic Recharge(Cont.)

filter time ($T_{RECHARGE}$). A charge cycle restarts when the battery voltage falls below 4.0V (which corresponds to approximately 80% to 90% battery capacity). This ensures that the battery is kept at or near a fully charged condition and eliminates the need for periodic charge cycle initiations. STAT output enters a strong pull-down state during recharge cycles.

Power Dissipation

The conditions that cause the TP4054 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:

$$PD = (V_{IN} - V_{BAT}) \times I_{BAT}$$

V_{IN} Bypass Capacitor

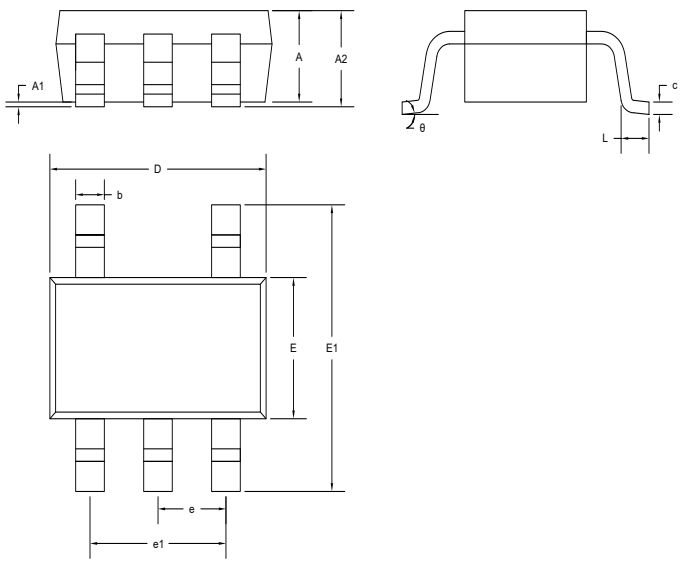
Many types of capacitors can be used for input bypassing. However, caution must be exercised when using multilayer ceramic capacitors. Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, high voltage transients can be generated under some start-up conditions, such as connecting the charger input to a live power source. Adding a 1.5Ω resistor in series with an X5R ceramic capacitor will minimize start-up voltage transients.

Layout Considerations

Once the charge cycle is terminated, the TP4054 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 4.0V (which corresponds to approximately 80% to 90% battery capacity). This ensures that the battery is kept at or near a fully charged condition and eliminates the need for periodic charge cycle initiations. STAT output enters a strong pull-down state during recharge cycles.

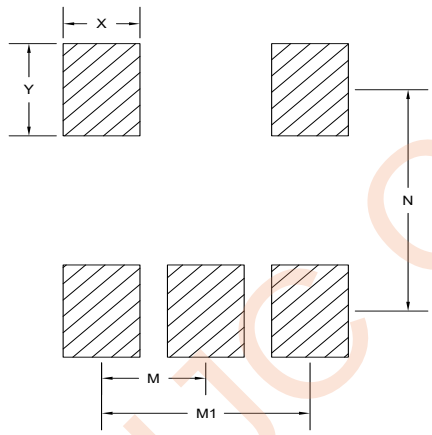
- For the main current paths as indicated in bold lines, keep their traces short and wide.
- Put the input capacitor as close as possible to the device pins (V_{IN} and GND).
- Connect all analog grounds to a command node and then connect the command node to the power ground behind the C_{OUT}.

Package Outline Dimensions (SOT-23-5L)



Symbol	Dimensions			
	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	0.889	1.295	0.035	0.051
A1	0	0.152	0.000	0.006
A2	1.05	1.15	0.041	0.045
b	0.356	0.559	0.014	0.022
c	0.080	0.254	0.003	0.010
D	2.692	3.099	0.106	0.122
E	1.397	1.803	0.055	0.071
E1	2.591	2.997	0.102	0.118
e	0.838	1.041	0.033	0.041
e1	1.90 BSC		0.075 BSC	
L	0.3	0.61	0.012	0.024
θ	0	8°	0	8°

Suggested Pad Layout



Symbol	Dimensions			
	Millimeters		Inches	
	Min.	Max.	Min.	Max.
X	0.85	0.85	0.033	0.033
Y	0.90	1.10	0.035	0.043
M	0.85	1.05	0.033	0.041
M1	1.80	2.0	0.071	0.079
N	2.3	2.5	0.091	0.098