Single 500mA Li-Ion Battery Charge IC

DESCRIPTION

SUM4054 is a constant-current/constant-voltage linear charger for single cell lithium-ion batteries. Its small package and low external component count make the SUM4054 ideally suited for portable applications. Furthermore, the SUM4054 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 4.2 V, and the charge current can be programmed externally with a single resistor.

When the input supply (wall adapter or USB supply) is removed, the SUM4054 automatically enters a low current state, dropping the battery drain current to less than 3 μA.

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.

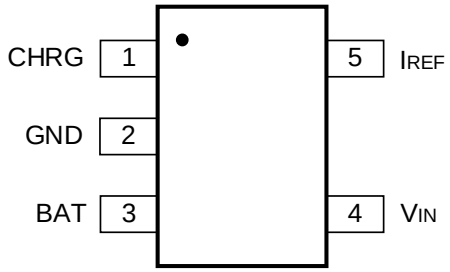
FEATURES

- Programmable Charge Current Up to 500 mA
- Preset 4.2 V Charge Voltage with ±1% Accuracy
- Complete Linear Charger for Single Cell Lithium-Ion Batteries
- When automatically enters a low current state, dropping the battery drain current to less than 3 μA
- Trickle current, constant current, constant voltage charge automatic change Its conforms to the charging specification
- Automatic Recharge
- Charge Status Output Pin
- 2.9 V Trickle Charge Threshold
- Reverse Battery Protection
- Available in SOT23-5 Package

ORDER INFORMATION

Model	Package	Ordering Number	Packing Option
SUM4054	SOT23-5	SUM4054KA5	Tape and Reel, 3000

PIN CONFIGURATION (Top View)

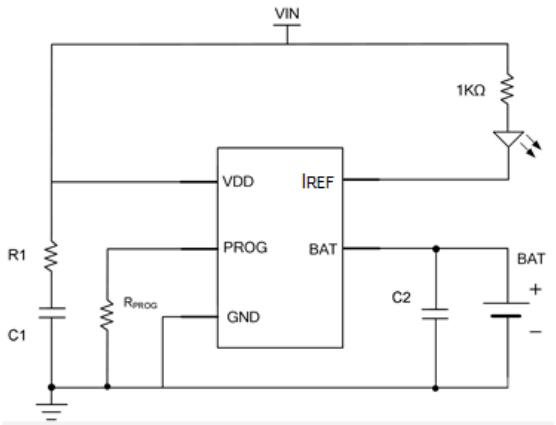


SOT23-5

PIN DESCRIPTIONS

Pin	Name	Function
1	CHRG	Charge status output.
2	GND	Ground.
3	BAT	Charger Output Pin. Connect this pin to the battery.
4	V_{IN}	Power Input.
5	I_{REF}	Charge-Current Programming and Monitoring Pin.

TYPICAL APPLICATIONS



Note1：Recommended data（R1 = 4.7 ~ 10 Ω，C1/C2 = 1 ~ 10 μF）.

ABSOLUTE MAXIMUM RATING

Parameter		Rating	Unit
Input Voltage		-0.3 to 9.0	V
Other pin voltage		-0.3 to 9.0	V
Maximum Junction Temperature		150	°C
Storage Temperature Range		-65 to 150	°C
Thermal Resistance		190	°C/W
ESD	HBM	2000	V

Stresses beyond those listed under “ABSOLUTE MAXIMUM RATINGS” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

CAUTION

This integrated circuit can be damaged by ESD if you don’t pay attention to ESD protection. SUMSEMI recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

SUMSEMI reserves the right to make any change in circuit design, specification or other related things if necessary without notice at any time. Please contact SUMSEMI sales office to get the latest datasheet.

RECOMMENDED OPERATING CONDITIONS

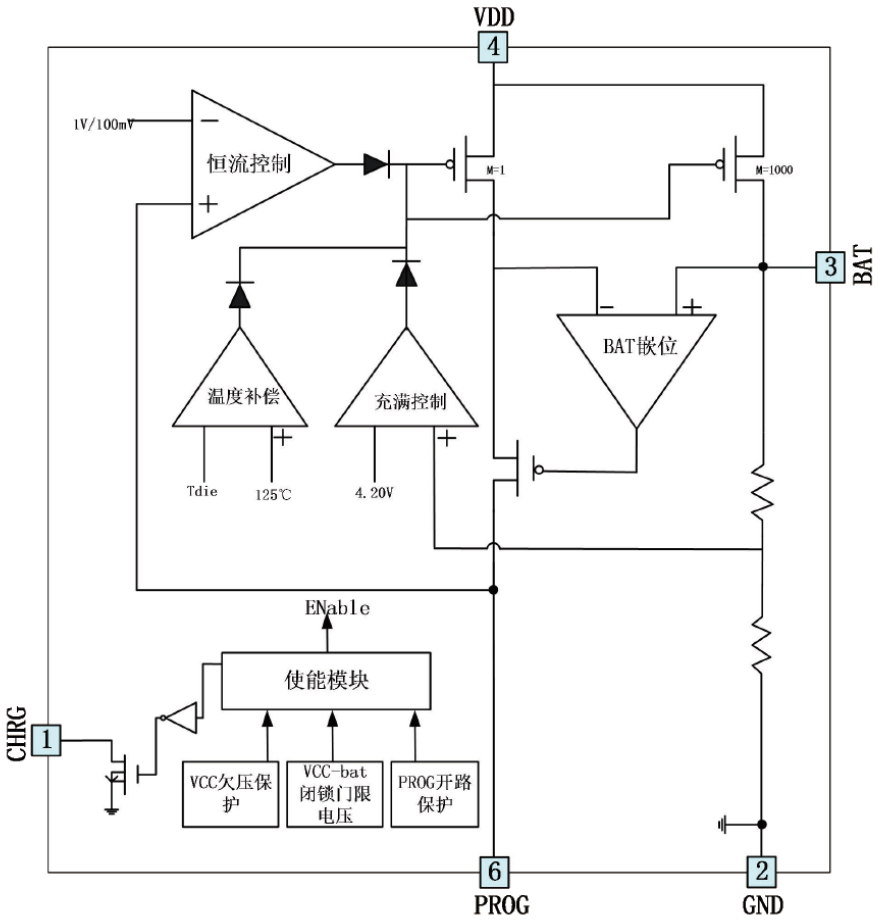
Parameter	Rating	Unit
Input Voltage	4.5 to 6.0	V
Maximum charging current	800	mA
Operating Ambient Temperature Range	-40 to 85	°C

ELECTRICAL CHARACTERISTICS

V_{IN} = 5 V, T_A = 25 °C, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{IN}	Input Supply Voltage		4.5	5.0	6.0	V
I_{IN}	Input Supply Current	Charge Mode, R_{IREF} = 4 kΩ		150	360	μA
		Standby Mode (Charge Terminated)		75	180	
		Stop Mode (I_{REF} no Connect, V_{IN} < V_{BAT}, V_{IN} <V_{UVLO})		45	100	
V_{FLOAT}	Regulated Output (Float) Voltage	V_{IN} = 5 V, R_{IREF} = 2 kΩ,	4.158	4.200	4.242	V
I_{BAT}	BAT Pin Current	V_{BAT} = 3.9 V,R_{IREF} = 2 kΩ,	450	500	550	mA
		V_{BAT} = 3.9 V,R_{IREF} = 3.3 kΩ,	270	300	330	mA
		V_{BAT} = 3.9 V,R_{IREF} = 10 kΩ,	90	100	110	mA
		V_{IN} floating or connect GND V_{BAT} = 3.9 V		2.5	3	μA
		V_{BAT} = -3.8 V (Reverse Battery), V_{IN} = NC		0.1		mA
I_{TRIKL}	Trickle Charge Current	V_{BAT} < V_{TRIKL}, R_{IRFE} = 2 kΩ	35	50	65	mA
V_{TRIKL}	Trickle Charge Threshold Voltage	V_{BAT} Rising	2.8	2.9	3.0	V
V_{TRHYS}	Trickle Charge Hysteresis Voltage	V_{BAT} Falling		150		mV
V_{UV}	V_{IN} Undervoltage Lockout	V_{IN} Rising	3.0	3.7	4.2	V
V_{UVHYS}	V_{IN} Undervoltage Lockout	V_{IN} Falling		170		mV
V_{ASD}	V_{IN} - V_{BAT} Lockout Threshold Voltage	V_{BAT} = 3.7 V, V_{IN} Rising		200		mV
		V_{BAT} = 3.7 V, V_{IN} Falling		90		mV
I_{TERM}	C/10 Termination Current	R_{IREF} = 2 kΩ	35	50	65	mA
V_{RECHRG}	Recharge BAT Threshold Voltage	V_{FLOAT} - V_{RECHRG}		150		mV
$t_{RECHARGE}$	Recharge Comparator Filter Time		0.6	1.5	3.0	ms
t_{TERM}	Termination Comparator Filter Time	I_{BAT} < 0.1I_{CHR}	0.6	1.5	3.0	ms
R_{DS_ON}	Drain-Source On-Resistance	V_{BAT} = 3.8V, I_{CHG} = 0.3A, R_{IRFE} = 2 kΩ		1000		mΩ
I_{IREF}				1		μA
OTC	Over temperature protection threshold	Junction Temperature		125		°C
V_{CHRG}	CHRG Pin Output Low Level			50	100	mV

BLOCK DIAGRAM



DETAILED DESCRIPTION

The SUM4054 is a single cell lithium-ion battery charger using a constant-current/constant-voltage algorithm. It can deliver up to 500 mA of charge current (using a good thermal PCB layout) with a final float voltage accuracy of±1%. The SUM4054 includes an internal P-channel power MOSFET and thermal regulation circuitry. No blocking diode or external current sense resistor is required; thus,the basic charger circuit requires only two external components.Furthermore, the SUM4054 is capable of operating from a USB power source.

Normal Charge Cycle

A charge cycle begins when the voltage at the VDD pin rises above the UVLO threshold level and a 1% program resistor is connected from the PROG pin to ground or when a battery is connected to the charger output. If the BAT pin is less than 2.9 V, the charger enters trickle charge mode.In this mode, the SUM4054 supplies approximately 1/10 the programmed charge current to bring the battery voltage up to a safe level for full current charging.

When the BAT pin voltage rises above 2.9 V, 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 (4.2 V), the SUM4054 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:

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

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

$$I_{BAT} = 1000* V_{PROG} / R_{PROG}$$

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 100 mV for longer than t_{TERM} (typically 1 ms), charging is terminated. The charge current is latched off and the SUM4054 enters standby mode, where the input supply current drops to 200 uA.(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 100 mV for short periods of time before the DC charge current has dropped to 1/10th the programmed value. The 1ms filter time (tTERM) 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 SUM4054 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 SUM4054 constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the 4.05 V recharge threshold (VRECHRG), 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)

The charge status output has three different states: strong pull-down (~10 mA), weak pull-down (~20 uA) and high impedance. The strong pull-down state indicates that the SUM4054 is in a charge cycle. Once the charge cycle has terminated, the pin state is determined by undervoltage lockout conditions. A weak pull-down indicates that VCC meets the UVLO conditions and the SUM4054 is ready to charge. High impedance indicates that the SUM4054 is in undervoltage lockout mode: either VCC is less than 100 mV above the BAT pin voltage or insufficient voltage is applied to the VCC 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 SUM4054 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 SUM4054. 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 VCC 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 charger in shutdown mode if VCC 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 VCC rises 100mV above the battery voltage.

Manual Shutdown

At any point in the charge cycle, the SUM4054 can be put into shutdown mode by removing RPROG thus floating the PROG pin. This reduces the battery drain current to less than 2 uA and the supply current to less than 50 uA. 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 as VCC is high enough to exceed the UVLO

conditions. The CHRG pin is in a high impedance state if the SUM4054 is in undervoltage lockout mode: either VCC is within 100 mV of the BAT pin voltage or insufficient voltage is applied to the VCC pin.

Automatic Recharge

Once the charge cycle is terminated, the SUM4054 continuously monitors the voltage on the BAT pin using a comparator with a 2 ms filter time (tRECHARGE). A charge cycle restarts when the battery voltage falls below 4.05 V (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. CHRG output enters a strong pulldown state during recharge cycles.

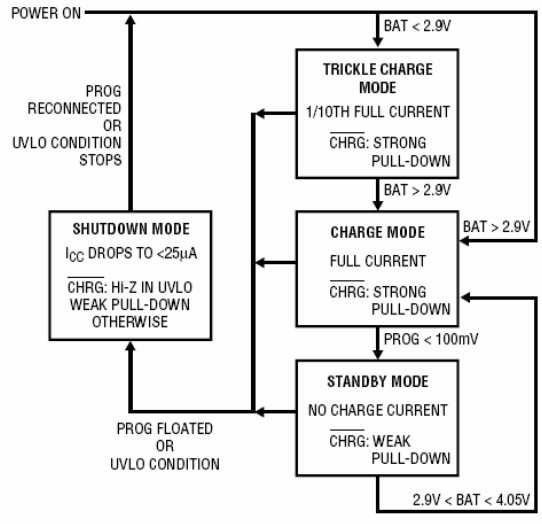
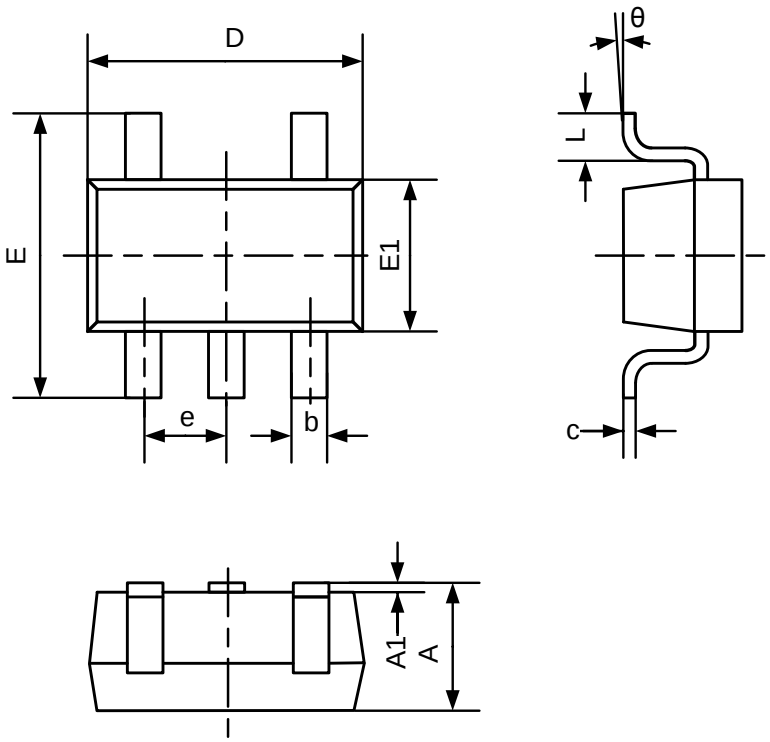


Figure 1. State Diagram of a Typical Charge Cycle

PACKAGE OUTLINE

SOT23-5



Symbol	Dimensions In Millimeters	
	Min	Max
A	1.050	1.250
A1	0.000	0.100
b	0.300	0.500
c	0.100	0.200
D	2.820	3.020
E	2.650	2.950
E1	1.500	1.700
e	0.950BSC	
L	0.300	0.600
θ	0°	8°