

Description

SM4354 is a complete single-cell lithium-ion battery linear charger operating in constant current / constant voltage mode. It integrates battery positive/negative reverse connection protection to safeguard the IC and end-user safety.

Built with internal PMOSFET architecture and anti-reverse charging circuitry, the device eliminates the requirement for an external sense resistor and blocking diode. Thermal feedback (based on IC internal die temperature) adjusts the charging current to limit IC temperature during high-power operation or high-temperature conditions. The charging voltage is fixed at 4.2 V, and the charging current can be externally set via a single resistor. After reaching the final float voltage, SM4354 automatically terminates the charging cycle when the charging current drops to 1/10 of the programmed value.

When the input voltage (AC adapter or USB power supply) is removed, SM4354 automatically enters a low-current state, reducing battery leakage current to less than 0.25 μA . The IC can also be set into shutdown mode to cut supply current down to 25 μA .

Other features of SM4354 include a charging current monitor, undervoltage lockout, automatic recharge, and a status pin to indicate charging completion and input power presence.

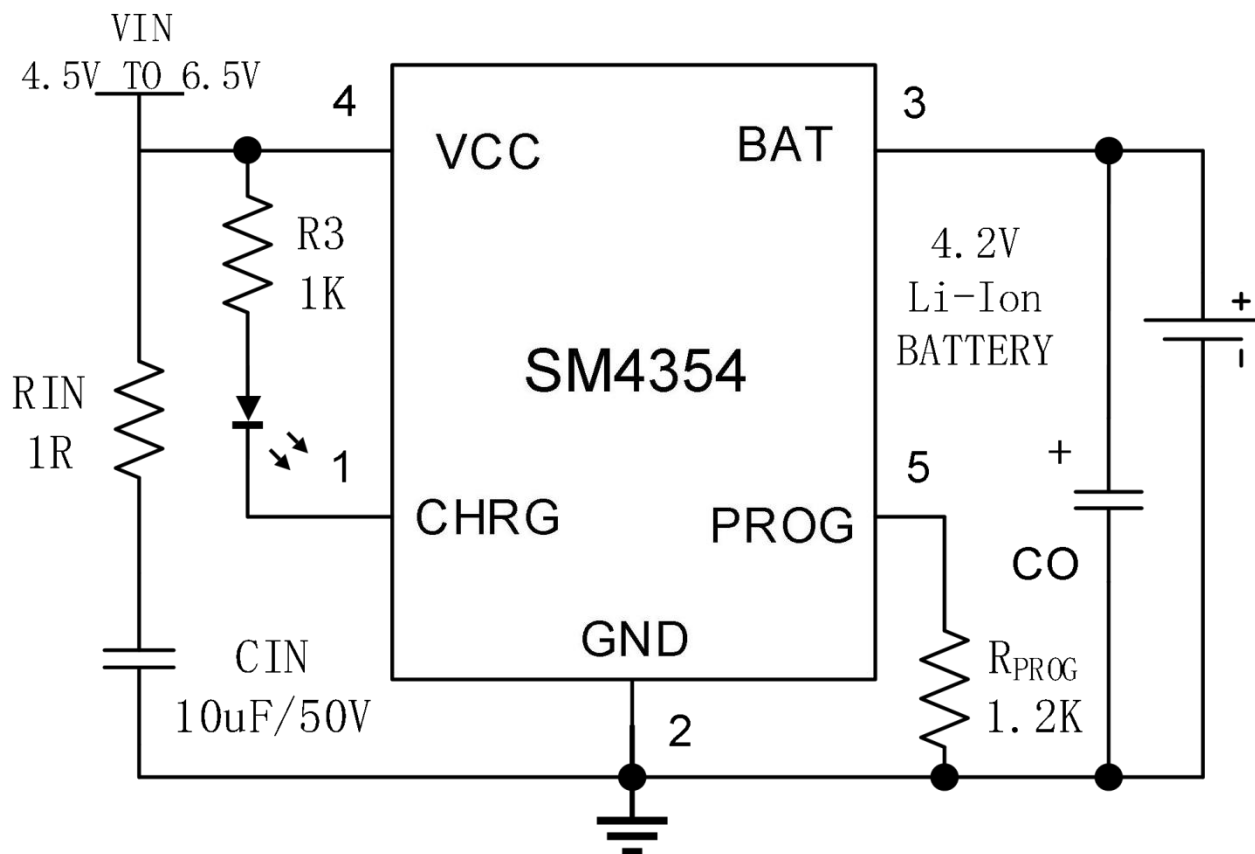
Features

- Programmable charging current up to 800 mA
- No external MOSFET, sense resistor or blocking diode required
- Constant current / constant voltage operation with thermal regulation to maximize charging rate without overheating risk
- Single-cell Li-ion battery charging directly from USB port
- Preset 4.2 V charging voltage with $\pm 1\%$ accuracy
- Charging current monitor output for battery capacity detection • Automatic recharge
- Input overvoltage protection for charging supply
- 2.9 V trickle charge threshold
- Soft-start to limit inrush current • Charge termination at C/10 current
- Package: SOT23-6
- 30 V pin voltage withstand rating

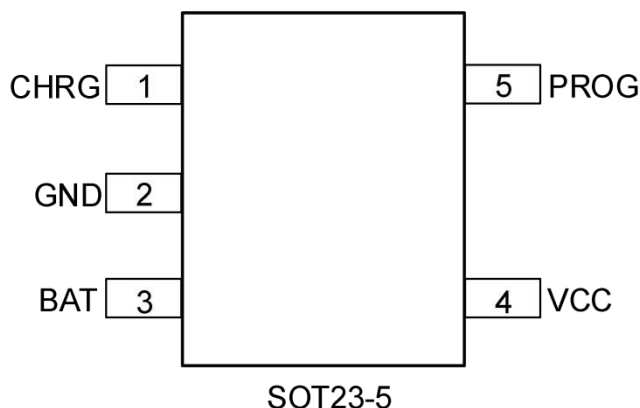
Applications

- Mobile phones, PDAs, MP3 players
- Charging docks, Bluetooth applications and other portable handheld devices

Typical Application Circuit



Pin Configuration



Pin Description

SOT23-5	Pin Name	Description
1	CHRG	Charging status indicator pin for open-drain output
2	GND	Ground
3	BAT	Charging current output pin
4	VCC	Power input pin
5	PROG	Constant current charging current setting and charging current monitoring terminal

Absolute Maximum Ratings ⁽¹⁾

Input Supply Voltage -0.3 V ~ 30 V
 Voltage on Other Pins -0.3 V ~ 6.0 V
 BAT -0.3 V ~ 12 V
 All other PINs. 1.6 A
 Working Temperature(TOP)..... -40 °C ~ +85 °C
 Storage Temperature (TSTG) -40 °C ~ +125 °C

Operating Range

VCC 4.5 V ~ 6.5 V

(1) The device may be damaged if the IC operates beyond the absolute maximum ratings. Operation at absolute maximum ratings or any conditions exceeding the recommended operating conditions is not recommended. Continuous operation under absolute maximum rating conditions may degrade device reliability. Absolute maximum ratings are merely stress rating limits.

Electrical Characteristics

(Unless otherwise specified, VIN=5 V, TA=25°C)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Input voltage range		Normal working voltage	4.5	5	6.5	V
Input Voltage Overvoltage Protection Threshold	V _{OVP}			6.5		V
Input voltage and current	I _Q	Charging Mode, R _{PROG} =1.5 k		300		μA
		Standby mode (Charging terminated)		100		μA
		Standby mode (R _{PROG} not connected, V _{CC} < V _{BAT} , or V _{CC} < V _{UV})		75		μA
Stable output (float charge) voltage	V _{FLOAT}	0°C ≤ T _A ≤ 85°C, I _{BAT} = 40 mA	4.16	4.2	4.24	V
BAT Pin current	I _{BAT}	R _{PROG} = 1.5 k, Current Mode		800		mA
		Standby mode, V _{BAT} = 4.2 V	0	2	3	μA
		Standby Mode (R _{PROG} no link)		0.25	0.35	μA
		Sleep Mode, V _{CC} = 0 V		0.25	0.35	μA
Trickle charging current	I _{TRIKL}	V _{BAT} < V _{TRIKL} , R _{PROG} = 1.5 k	140	160	180	mA
Trickle charging threshold voltage	V _{TRIKL}	R _{PROG} = 1.5 k, V _{BAT} Raising	2.75	2.93	3.1	V
Trickle charging hysteresis voltage	V _{TRHYS}	R _{PROG} = 1.5 k	120	150	180	mV
VCC under-voltage lockout threshold voltage	V _{UV}	V _{CC} from low to high		3.8		V
VCC under-voltage lockout hysteresis voltage	V _{UVHYS}			280		mV
VCC-VBAT locking threshold voltage	V _{ASD}	V _{CC} from low to high		140		mV
		V _{CC} from high to low	50	100		mV
Battery reverse polarity protection voltage	V _{REV}	V _{BAT} from high to low, V _{BAT} -V _{GND}		-230		mV
Battery reverse polarity protection hysteresis voltage	V _{REHVYS}	V _{BAT} from low to high, V _{BAT} -V _{GND}		-200		mV
C/10 termination current threshold	I _{TERM}	R _{PROG} = 1.5 k		80		mA
PROG pin Voltage	V _{PROG}	BAT=4.0 V, Current Mode	0.9	1.0	1.1	V
CHRG pin output low voltage	V _{CHRG}	I _{CHRG} = 5 mA		0.35	0.6	V
Rechargeable battery threshold voltage	ΔV _{RECHRG}	V _{FLOAT} - V _{RECHRG}		100		mV
The junction temperature of the chip	T _{LIM}	°C		120		°C
Power FET conduction resistance	R _{ON}			0.6		mΩ
Soft-start time	t _{SS}	I _{BAT} = 0 to I _{BAT} = 1000V/R _{PROG}		100		μs
Recharge comparator filter time	t _{RECHARGE}	V _{BAT} high to low	0.4	1.0	2.5	ms
Comparator filter termination time	t _{TERM}	I _{BAT} reduced to I _{CHG} /10	0.4	1.0	2.5	ms
PROG pin pull-up current	I _{PROG}			1.0		μA

Functional Description

SM4354 is a complete constant-current / constant-voltage linear charger for single-cell lithium-ion batteries. It supports charging current up to 800mA with a well thermally optimized PCB layout, and the float voltage accuracy reaches $\pm 1\%$. The SM4354 integrates an internal P-channel power MOSFET and thermal regulation circuitry, eliminating the requirement for a blocking diode and external current sense resistor. Hence, the basic charger circuit only requires two external components.

Normal Charging Cycle

A charging cycle initiates when the VCC pin voltage rises above the UVLO threshold, a 1% precision programming resistor is connected between the PROG pin and GND, or a battery is connected to the charger output terminal. If the voltage of the BAT pin is lower than 2.9V, the charger enters trickle charge mode. Under this mode, SM4354 supplies approximately 2/10 of the programmed charging current to boost the battery voltage to a safe level for full-current charging.

Charge Current Programming

The charging current is set by a resistor connected between the PROG pin and ground. The battery charging current is 1200 times the output current of the PROG pin. The charging current sourced from the BAT pin can be determined at any time by monitoring the voltage on the PROG pin according to the following formula:

$$P_{PROG} = \frac{1200}{I_{CHG}} I_{CHG} = \frac{1200}{P_{PROG}}$$

Charge Termination

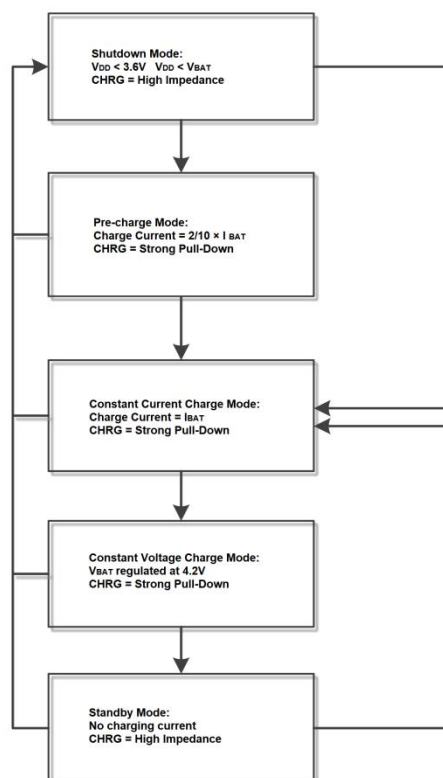
HT3110 integrates an internal thermal protection function. During charging, the IC will automatically reduce

A charge cycle terminates when the charging current drops to 1/10 of the programmed value after reaching the final float voltage. This condition is detected by monitoring the PROG pin via an internal filtered comparator. Charging stops when the voltage at the PROG pin remains below 100 mV for longer than t_{TERM} (typically 1.8 ms). The charging current is cut off, and SM4354 enters standby mode, where the input supply current drops to 200 μ A.

(Note: C/10 termination is invalid under trickle charge mode and thermal limit mode.)

During charging, transient loads on the BAT pin may briefly pull the PROG pin voltage below 100 mV before the DC charging current decays to 1/10 of the programmed level. The 1.8 ms deglitch time (t_{TERM}) of the termination comparator prevents such transient loads from causing premature charge termination. Once the average charging current falls below 1/10 of the programmed value, SM4354 terminates the charge cycle and stops sourcing current through the BAT pin. Under this condition, all loads connected to the BAT pin must be powered by the battery.

In standby mode, SM4354 continuously monitors the voltage at the BAT pin. If the voltage falls below the recharge threshold (V_{RECHRG}), a new charge cycle initiates and current is supplied to the battery again. To manually restart a charge cycle in standby mode, the input supply must be cycled (disconnected and reconnected), or the charger shall be turned off and restarted by controlling the PROG pin. The state diagram of a typical charging cycle is shown in the following figure.



Charge Status Indicator

When the status indication function is not required, tie the unused status indication outputs to ground. The charging status output has two distinct states: pull-down (approx. 10 mA) and high impedance. The pull-down state indicates that the SM4354 is in a charging cycle. Once the charging cycle terminates, the pin state is determined by the undervoltage lockout condition. The high-impedance state means SM4354 is in undervoltage lockout mode: either Vcc is less than 100 mV higher than the voltage at the BAT pin, or the voltage applied to the Vcc pin is insufficient.

Thermal Limiting (Internal Die Temperature)

If the IC temperature rises to the preset threshold of 120°C, the internal thermal feedback loop reduces the charging current. This function prevents overheating of the SM4354 and allows users to increase the upper limit of the board's power handling capability without risk of damaging the device. Given that the charger automatically reduces current under worst-case conditions, the charging current can be configured based on typical (rather than worst-case) ambient temperature.

Undervoltage Lockout (UVLO)

An internal UVLO circuit monitors the input voltage and keeps the charger in shutdown mode until VCC rises above the UVLO threshold. The UVLO circuit maintains the charger in a shutdown

state. If the UVLO comparator toggles, the charger will not exit shutdown mode until VCC is at least 100 mV higher than the battery voltage.

Automatic Recharge

Once a charge cycle is terminated, the SM4354 continuously monitors the voltage at the BAT pin via a comparator with a 1ms deglitch time. A new charge cycle initiates when the battery voltage drops below 4.05V (approximately 80% to 90% of full battery capacity). This ensures the battery is maintained at or near a full-charge state and eliminates the need for periodic manual charge triggering. During the recharge cycle, the CHRG pin is pulled strongly low.

Power Considerations

The IC die temperature depends on multiple factors including ambient temperature, PCB layout, load conditions and package type. Power dissipation and die temperature can be calculated by the formulas shown below:

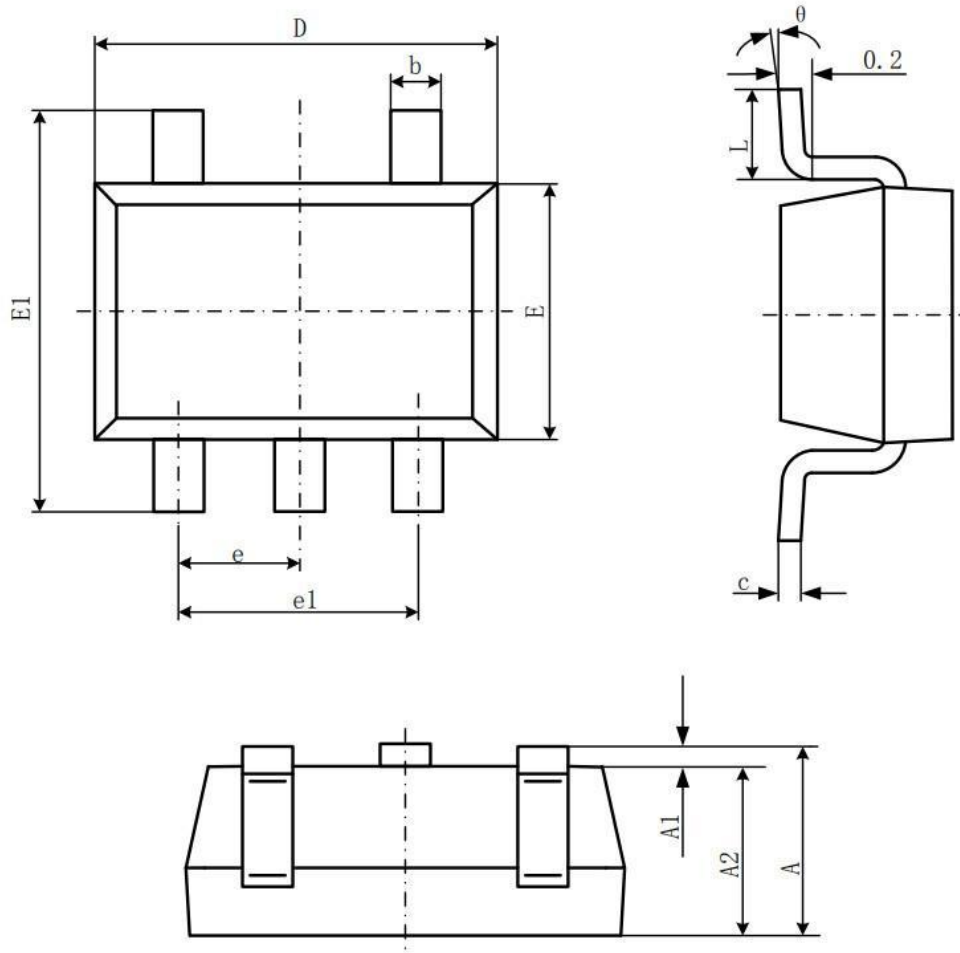
$$PD = R_{DS(ON)} \times I_{OUT}^2$$

The PD junction temperature can be calculated using the following formula:

$$T_J = PD \times \theta_{JA} + T_A$$

Where: T_J is the chip junction temperature, T_A is the ambient temperature, and θ_{JA} is the package thermal resistance.

Package Size: SOT23-5



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.05	1.25	0.041	0.049
A1	0	0.1	0	0.004
A2	1.05	1.15	0.041	0.045
b	0.3	0.5	0.012	0.02
c	0.1	0.2	0.004	0.008
D	2.82	3.02	0.111	0.119
E	1.5	1.7	0.059	0.067
E1	2.65	2.95	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.8	2	0.071	0.079
L	0.3	0.6	0.012	0.024
θ	0°	8°	0°	8°

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