



800mA Standalone Linear Li-Ion Battery Charger

Features

- Constant-Current/Constant-Voltage Operation with Thermal Regulation to Maximize Charge Rate Without Risk of Overheating
- No MOSFET, Sense Resistor or Blocking Diode Required
- Complete Linear Charger in SOT Package for Single Cell Lithium-Ion Batteries
- Charges Single Cell Li-Ion Batteries Directly from USB Port
- Charge Current Monitor Output for Gas Gauging
- Programmable Charge Current Up to 800mA
- Charge Status Output Pin
- C/10 Charge Termination
- Automatic Recharge
- Preset 4.2V Charge Voltage with $\pm 1\%$ Accuracy
- 35 μ A Supply Current in Shutdown
- 2.9V Trickle Charge Threshold
- Soft-Start Limits Inrush Current
- Available in 5-Lead SOT-23 Package
- RoHS Compliant and Lead (Pb) Free

Applications

- Cellular Telephones
- Charging Docks and Cradles
- Bluetooth Application
- Wearable Application

General Description

The cst4084 is a complete constant-current/constant-voltage linear charger for single cell lithium-ion batteries. Its SOT package and low external component count make the cst4084 ideally suited for portable applications. Furthermore, the cst4084 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 cst4084 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 cst4084 automatically enters a low current state, dropping the battery drain current to less than 1 μ A. The cst4084 can be put into shutdown mode, reducing the supply current to 35 μ A. 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.



Typical Application Circuit

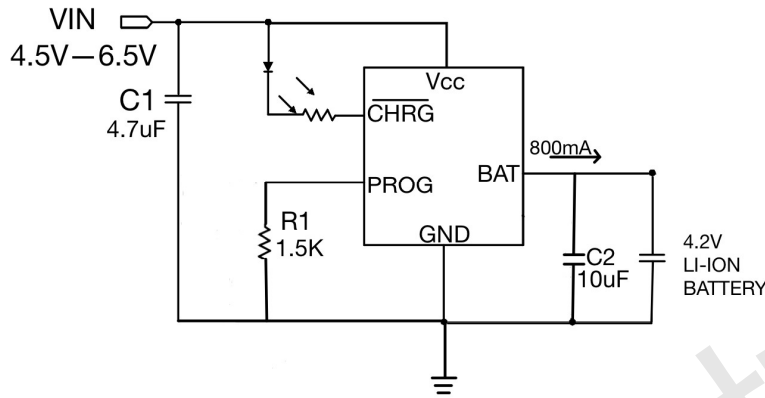


Figure 1. Typical Application Circuit

Pin Description

Pin Configuration

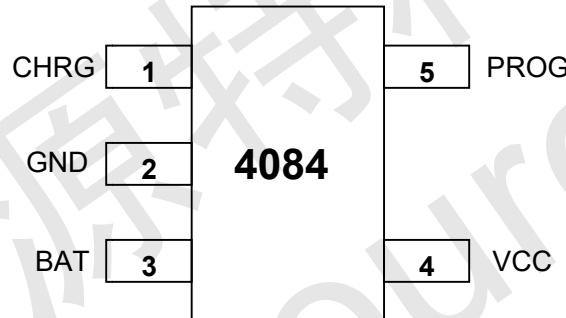


Figure 2. Pin Configuration

Pin Description

Pin	Name	Function
1	CHRG	Open-Drain Charge Status Output Pin
2	GND	Ground
3	BAT	Charge Current Output Pin
4	VCC	Positive Input Supply Voltage Pin
5	PROG	Charge Current Program, Charge Current Monitor and Shutdown Pin

Order Information

Marking	Part No.	Model	Description	Package	T/R Qty
C84AS		cst4084	cst4084 Linear Li-Ion Battery Charger, 800mA, Preset 4.2V, 1 Charge Status, SOT23-5	SOT23-5	3000 PCS



Specifications

Absolute Maximum Ratings ^{(1) (2)}

Item	Min	Max	Unit
VCC Input Voltage	-0.3	10	V
PROG Voltage	-0.3	VCC+0.3	V
BAT Voltage	-0.3	7	V
Voltage	-0.3	10	V
Power dissipation	Internally Limited		
Operating Junction Temperature, T _J	-40	150	°C
Storage Temperature, T _{stg}	-65	125	°C
Operating Temperature Range	-40	85	°C
Lead Temperature (Soldering, 10sec.)		260	°C

Note (1): Exceeding these ratings may damage the device.

Note (2): The device is not guaranteed to function outside of its operating conditions.

ESD Ratings

Item	Description	Value	Unit
V(ESD-HBM)	Human Body Model (HBM) ANSI/ESDA/JEDEC JS-001-2014 Classification, Class: 2	±2000	V
V(ESD-CDM)	Charged Device Model (CDM) ANSI/ESDA/JEDEC JS-002-2014 Classification, Class: C0b	±200	V
ILATCH-UP	JEDEC STANDARD NO.78E APRIL 2016 Temperature Classification, Class: I	±150	mA

Thermal Information

Item	Description	Value	Unit
R _{θJA}	Junction-to-ambient thermal resistance ^{(1) (2)}	180	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	130	°C/W
R _{θJB}	Junction-to-board thermal resistance	45	°C/W
ψ _{JT}	Junction-to-top characterization parameter	35	°C/W
ψ _{JB}	Junction-to-board characterization parameter	45	°C/W

Note (1): The package thermal impedance is calculated in accordance to JESD 51-7.

Note (2): Thermal Resistances were simulated on a 4-layer, JEDEC board.



Electrical Characteristics^{(1) (2) (3)}

$V_{CC} = 5$, $T_A = 25^{\circ}\text{C}$, unless otherwise noted.

Parameter	Symbol	Test Conditions	Min	Typ.	Max	Unit
Input Supply Voltage	V_{CC}		4.0	5.0	6.5	V
Input Supply Current	I_{CC}	Charge Mode (Note 4), $R_{PROG} = 12\text{k}$		240	500	μA
		Standby Mode (Charge Terminated)		50	100	μA
		Shutdown Mode (R_{PROG} Not Connected, $V_{CC} < V_{BAT}$, or $V_{CC} < V_{UV}$)		35	70	μA
Regulated Output (Float) Voltage	V_{FLOAT}	$0^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$, $I_{BAT} = 40\text{mA}$	4.158	4.2	4.242	V
BAT Pin Current	I_{BAT}	$R_{PROG} = 2.4\text{k}$, Current Mode	465	500	535	mA
		$R_{PROG} = 1.5\text{k}$, Current Mode	750	800	850	mA
		Standby Mode, $V_{BAT} = 4.2\text{V}$	0	-2.5	-6	μA
		Sleep Mode, $V_{CC} = 0\text{V}$		0	1	μA
		Shutdown Mode (R_{PROG} Not Connected)		1	2	μA
Trickle Charge Current	I_{TRIKL}	$V_{BAT} < V_{TRIKL}$, $R_{PROG} = 2.4\text{k}$	40	50	60	mA
		$V_{BAT} < V_{TRIKL}$, $R_{PROG} = 1.5\text{k}$	75	80	85	mA
Trickle Charge Threshold Voltage	V_{TRIKL}	$R_{PROG} = 10\text{k}$, V_{BAT} Rising	2.8	2.9	3.0	V
Trickle Charge Hysteresis Voltage	V_{TRHYS}	$R_{PROG} = 10\text{k}$	60	80	110	mV
V_{CC} Undervoltage Lockout Threshold	V_{UV}	From V_{CC} Low to High	3.7	3.8	3.92	V
V_{CC} Undervoltage Lockout Hysteresis	V_{UVHYS}		150	200	300	mV
Manual Shutdown Threshold Voltage	V_{MSD}	PROG Pin Rising	1.15	1.21	1.30	V
		PROG Pin Falling	0.9	1.0	1.1	V
$V_{CC} - V_{BAT}$ Lockout Threshold Voltage	V_{ASD}	V_{CC} from Low to High	70	100	140	mV
		V_{CC} from High to Low	5	30	50	mV
C/10 Termination Current Threshold	I_{TERM}	$R_{PROG} = 2.4\text{k}$ (Note 5)	0.085	0.10	0.115	mA/mA
		$R_{PROG} = 1.5\text{k}$	0.085	0.10	0.115	mA/mA
PROG Pin Voltage	V_{PROG}	$R_{PROG} = 1.5\text{k}$, Current Mode	0.93	1.0	1.07	V
CHRG Pin Weak Pull-Down Current	I_{CHRG}	$V_{CHRG} = 5\text{V}$	25	30	35	μA
CHRG Pin Output Low Voltage	V_{CHRG}	$I_{CHRG} = 5\text{mA}$		0.35	0.6	V
Recharge battery threshold voltage protection	ΔV_{RECHRG}	$V_{FLOAT} - V_{RECHRG}$		1	200	mV
Recharge Comparator Filter Time	$t_{RECHARGE}$	V_{BAT} High to Low	0.8	1.8	4	mS



Termination Filter Time	Comparator t_{TERM}	I_{BAT} Falling Below $I_{CHG}/10$	0.63	1.4	3	mS
Soft-Start Time	T_{SS}	$I_{BAT} = 0$ to $I_{BAT} = 1000V/R_{PROG}$		100		μS
PROG Pin Pull-Up Current	I_{PROG}			3		μA

Note (1): Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

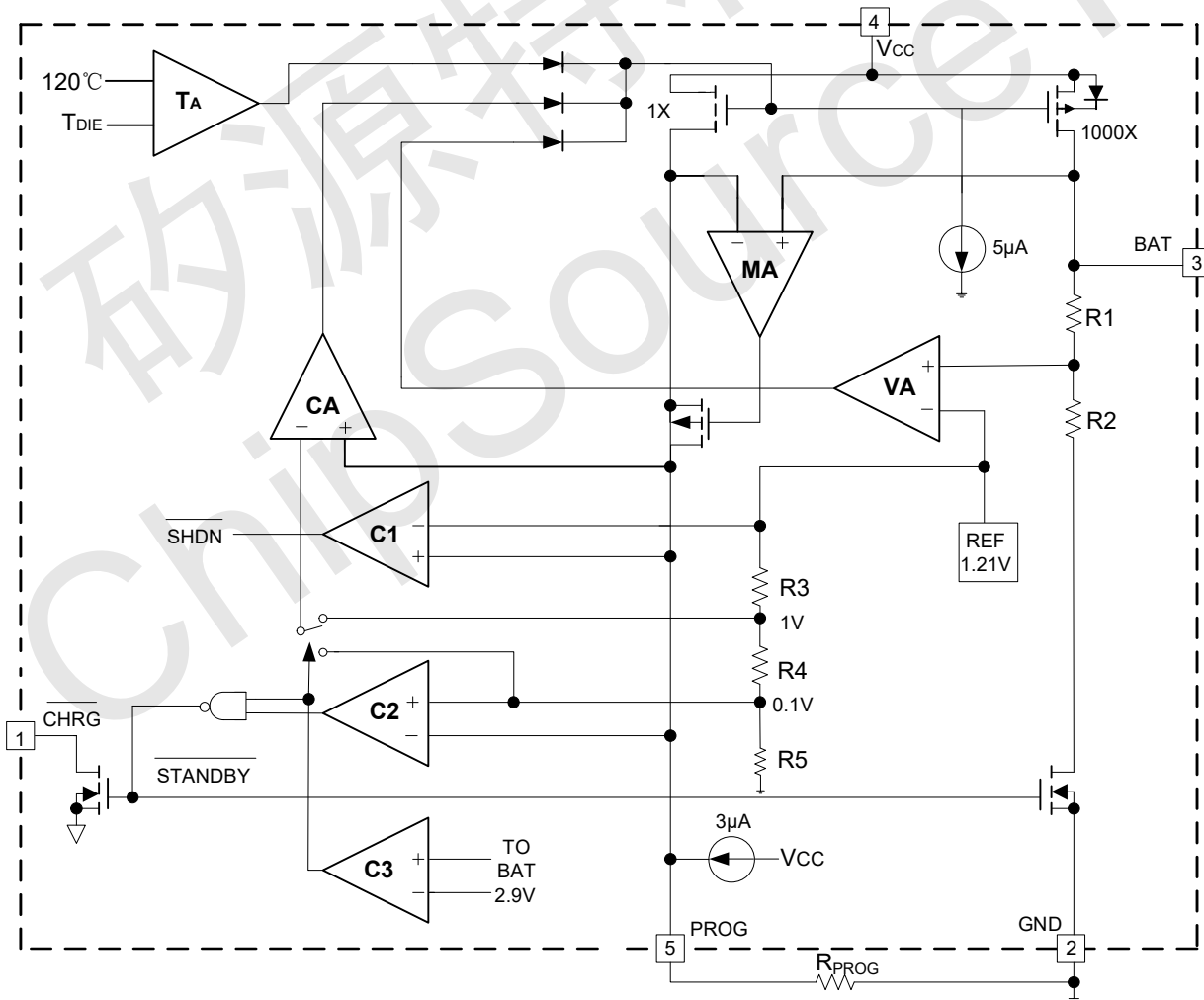
Note (2): The cst4084 is guaranteed to meet performance specifications from 0°C to 70°C. Specifications over the -40°C to 85°C operating temperature range are assured by design, characterization and correlation with statistical process controls.

Note (3): See Thermal Considerations.

Note (4): (Charge Mode : $I_{CC} = I_{VCC} - I_{BAT}$) Supply current includes PROG pin current (approximately 100 μA) but does not include any current delivered to the battery through the BAT pin (approximately 100mA).

Note (5): t_{TERM} is expressed as a fraction of measured full charge current with indicated PROG resistor

Functional Block Diagram





Functions Description

The cst4084 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 cst4084 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 cst4084 is capable of operating from a USB power 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 charger output. If the BAT pin is less than 2.9V, the charger enters trickle charge mode. In this mode, the cst4084 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 2.9V, 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 cst4084 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 1200 times the current out of the PROG pin. The program resistor and the charge current are calculated using the following equations:

$$R_{PROG} = \frac{1200V}{I_{CHG}} \quad I_{CHG} = \frac{1200V}{R_{PROG}}$$

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

$$I_{BAT} = \frac{V_{RPROG}}{R_{RPROG}} \cdot 1200$$

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 tTERM (typically 1ms), charging is terminated. The charge current is latched off and the cst4084 enters standby mode, where the input supply current drops to 200 μ 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 1/10th 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 cst4084 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 cst4084 constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the 4.05V 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 4 shows the state diagram of a typical charge cycle.

Charge Status Indicator

The charge status output has three different states: strong pull-down (~10mA), weak pull-down (~20μA) and high impedance. The strong pull-down state indicates that the cst4084 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 cst4084 is ready to charge. High impedance indicates that the cst4084 is in undervoltage lockout mode: either VCC is less than 100mV 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.

Charge Status Summary

Condition	LED
Battery charging	ON
Charge complete (done)	OFF
V _{CC} Undervoltage	OFF
NO Battery	SCINTILLATION(20Hz)

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 cst4084 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 cst4084. 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 30mV 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 cst4084 can be put into shutdown mode by removing RPROG thus floating the PROG pin. This reduces the battery drain current to less than 2μA and the supply current to less than 50μA. A new charge cycle can be initiated by reconnecting the program resistor. In manual shutdown, the CHRГ pin is in a weakpull-down state as long as VCC is high enough to exceed the UVLO conditions. The CHRГ pin is in a high impedance state if the cst4084 is in undervoltage lockout mode: either VCC is within 100mV of the BAT pin



voltage or insufficient voltage is applied to the VCC pin.

Automatic Recharge

Once the charge cycle is terminated, the cst4084 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 charged condition and eliminates the need for periodic charge cycle initiations. CHRГ output enters a strong pulldown state during recharge cycles.

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