UCT3146

5V 1A Standalone Linear Li-ion Battery Charger

GENERAL DESCRIPTION

The UCT3146 is a highly integrated 5V 1A Li-ion battery linear charging management device.

The UCT3146 charges a battery in three phases: trickle charging, constant current, and constant voltage. No external sense resistor is needed, and no blocking diode is required. The thermal feedback regulates the charging current to limit the chip temperature during high power operation or high ambient temperature to maximize the charge rate without risk of overheating. The charge voltage is fixed at 4.2 or 4.3V, and the charge current can be programmed externally with a single resistor. The UCT3146 automatically terminates the charge cycle when the charge current drops to 1/10 of the programmed value after the final float voltage is reached, and automatically re-starts the charge if the battery voltage falls below an internal threshold.

The UCT3146 is available in ESOP8 package.

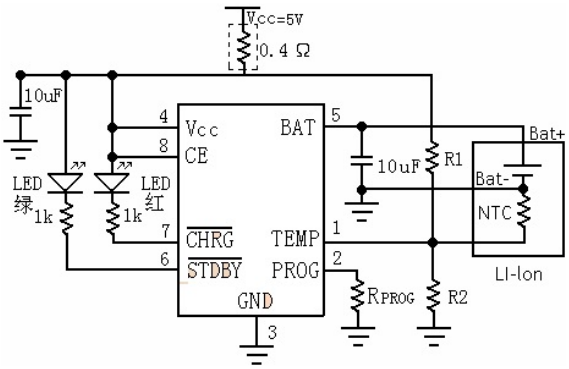
FEATURES

- Charges Single Cell Li-Ion Batteries Directly from USB Port
- Programmable Charge Current Up to 1.2A
- No external 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/4.3V Charge Voltage with ±1% tolerance
- ESOP8 Package

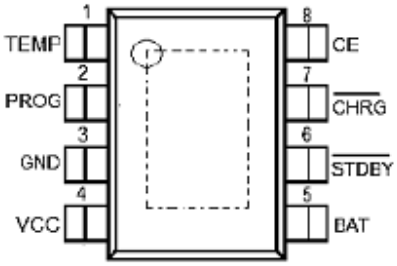
APPLICATIONS

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

TYPICAL APPLICATION CIRCUIT



PIN ASSIGNMENT



■ 引脚功能描述

PIN No	SYMBOL	DESCRIPTTION
1	TEMP	Temperature Sense Input
2	PROG	Charge Current Program, Charge Current Monitor and Shutdown Pin.
3	GND	Ground
4	VCC	Power Supply Input.
5	BAT	Charge Current Output.
6	STDBY	Open-Drain Standby Status Output.
7	CHRG	Open-Drain Charges Status Output.
8	CE	Chip Enable

ABSOLUTE MAXIMUM RATINGS (Note 1)

SYM	PARAMETER	VALUE	Units
V_{CC}	Input supply voltage	8	V
V_{PROG}	PROG & CE & TEMP Voltage	VCC+0.3	V
V_{BAT}	BAT Voltage	8	V
V_{CHRG}	CHRG & STDBY Voltage	8	V
D_{SC}	BAT Short-Circuit Duration	Continuous	
I_{BAT}	BAT Pin Current	1.2	A
I_{PROG}	PROG Pin Current	1200	μA
Tj	Maximum Junction Temperature	125	℃
Ts	Storage Temperature Range	-65 to 125	℃
T_{Lead}	Lead Temperature, soldering, 10Sec	260	℃
P_{TR}	Package Thermal Resistance, ESOP8 θ_{JA}	110	℃ /W

RECOMMENDED OPERATING RANGE (Note 2)

SYMBOL	PARAMETER	VALUE	Units
V_{CC}	Input supply voltage	4.5 to 7	V
Tj	Junction Temperature	-40 to +85	℃

Note1: Absolute Maximum Ratings are threshold limit values that must not be exceeded even for an instant under any condition. Moreover, such values for any two items must not be reached simultaneously. Operation above these absolute maximum ratings may cause degradation or permanent damage to the device. These are stress ratings only and do not necessarily imply functional operation below these limits.

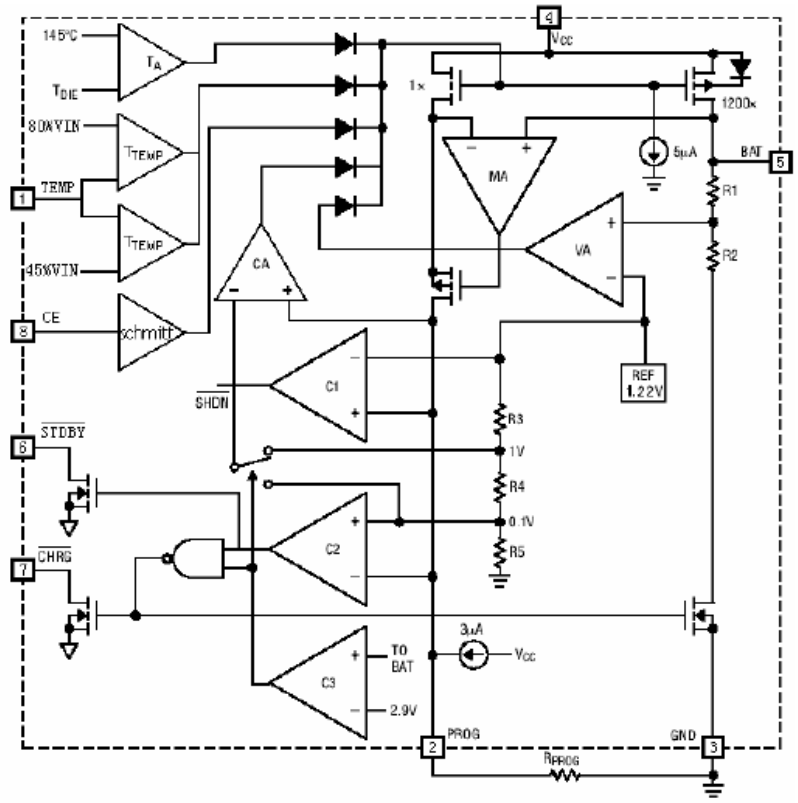
Note 2: Recommended operating Range indicates conditions for which the device is functional, but does not guarantee specific performance limits.

ELECTRICAL CHARACTERISTICS

T_A=25℃, V_{CC}=5V, unless otherwise noted

SYMBOL	PARAMETERS	CONDITIONS		MIN	TYP	MAX	UNITS
V_{CC}	Input Supply Voltage			4.5		7	V
I_{CC}	Input Supply Current	Charge Mode, R_{PROG} =10K			110	600	μA
		Standby Mode			70		μA
		Shut Down Mode: R_{PROG} Not Connected, V_{CC}<$V_{BAT,}$ or V_{CC}<V_{UV}			20	40	μA
V_{FLOAT}	Regulated Output Voltage	0℃≤T_A≤85℃	UCT3146-42	4.158	4.2	4.242	V
			UCT3146-43	4.257	4.3	4.343	
I_{BAT}	BAT pin Current	R_{PROG} =10K, Current Mode			100		mA
		R_{PROG} =2K, Current Mode			500		mA
		Standby Mode, V_{BAT} =V_{FLOAT}		0	±1	±5	μA
		Shutdown Mode(R_{PROG} Not Connected)			±0.5	±5	μA
		Sleep Mode, V_{CC} =0V			±1	±5	μA
I_{TRIKL}	Trickle Charge Current	V_{BAT} < V_{TRIKL}, R_{PROG} =2K			50		mA
V_{TRIKL}	Trickle Charge Threshold	R_{PROG} =10K, V_{BAT} Rising		2.8	2.9	3.0	V
V_{UV}	UVLO Threshold	V_{CC} from low to high			4.05		V
V_{UVHYS}	UVLO Hysteresis				200		mV
V_{MSD}	Manual Shutdown Threshold Voltage	PROG Pin Rising			1.25		V
		PROG Pin Falling			1.2		V
V_{ASD}	V_{CC} – V_{BAT} Lockout Threshold Voltage	V_{CC} From Low to High			100		mV
		V_{CC} From High to Low			30		mV
I_{TERM}	C/10 Termination Current Threshold	R_{PROG} =10K			10		mA
		R_{PROG} =2K			50		mA
V_{PROG}	PROG Pin Voltage	R_{PROG} =10K, Current Mode		0.9	1.0	1.1	V
V_{CHRG}	CHRG Low Voltage	I_{CHRG}=5mA			0.15	0.6	V
V_{STDBY}	STDBY Low Voltage	I_{CHRG}=5mA			0.15	0.6	V
V_{RECHRG}	Recharge Battery Threshold				4.05		V
V_{TEMPH}	TEMP HIGH Voltage				2		V
V_{TEMPL}	TEMP LOW Voltage				4		V
T_{LIM}	Thermal Protection				120		℃
R_{DSON}	On Resistor of MOSFET				600		mΩ
t_{SS}	Soft-Start time	I_{BAT} =0 to I_{BAT} =100V/ RPROG			20		μs
$T_{RECHARGE}$	Recharge Filter Time	V_{BAT} High to Low			1		ms
T_{TERM}	Termination Filter Time	I_{BAT} falling below I_{CHG} /10			1		ms
I_{PROG}	PROG Pull-Up Current				1		μA

SIMPLIFIED BLOCK DIAGRAM



OPERATION DESCRIPTION

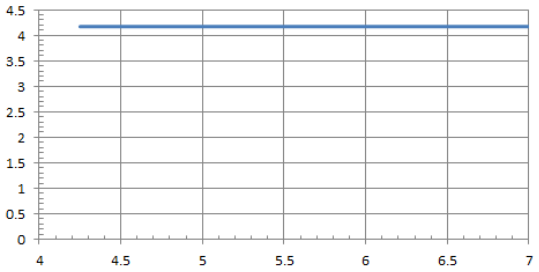
The UCT3146 is a standalone linear Li-ion battery charger with thermal regulation. One external 1% precision resistor is required to set the charging current value. When the voltage at the VCC pin rises above the UVLO threshold, the normal charging cycle begins. If the battery voltage is less than 2.9V, the device will operate in a trickle charging mode. The charging current in the trickle charging mode is 1/10 of the programmed value, which effectively protects the battery from damage and prolongs its lifetime. When the voltage at the BAT pin rises above 2.9V, the charger enters the constant-current mode in which case the charging current equals to the programmed value. Once the voltage at the BAT pin reaches V_{FLOAT}, the charger goes into the constant voltage mode where the charging current decreases. Once the charging current drops to 1/10 the programmed value, the charging cycle ends.

After a charge cycle is complete and the charging operation is terminated, the UCT3146 keeps monitoring the BAT voltage. It will recharge the battery as soon as the BAT voltage drops below 4.05V. The UCT3146 includes a soft-start circuit to minimize the inrush current at the start of a charge cycle. When the PROG pin is floating, the charger goes into the shutdown mode. It acts as chip enable pin.

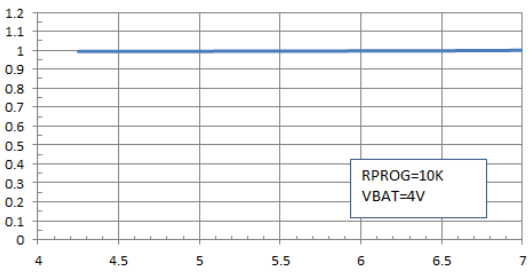
TYPICAL OPERATING CHARACTERISTICS

Note: Typical characteristics are obtained under the following conditions unless otherwise noted.

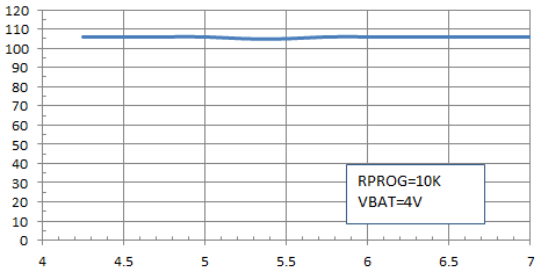
VFLOAT vs VCC



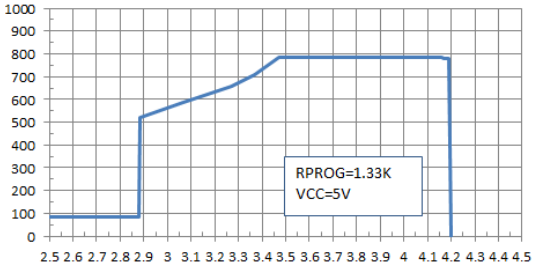
VPROG vs VCC



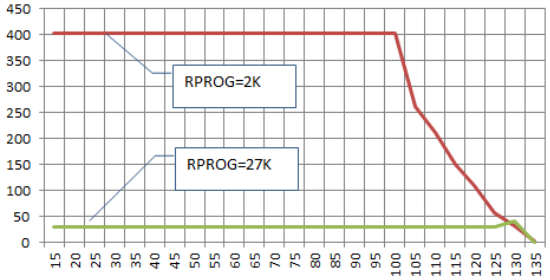
IBAT vs VCC



IBAT vs VBAT



IBAT vs TEMP



APPLICATION INFORMATION

Adjusting Charging Current

The charging current is programmed using 1% precision resistor from PROG pin to ground. The charging current and the programming resistor are calculated using the following equations:

R_{PROG}=1000V/I_{CHG},

I_{CHG}=1000V/R_{PROG}

Charge and Standby status indicator

The UCT3146 has two open-drain output pins: CHRG and STDBY. By connecting to a red and a green LED to them, they are able to be combined to indicate the Battery charging status as following table.

Status	CHRG pin RED LED	STDBY pin Green LED
Charging	Lighting	Dark
Full	Dark	Lighting
No battery but with capacitor on BAT pin	Blink	Lighting
No battery, No capacitor on BAT pin	Lighting(fast Blink)	Lighting
Over or Under TEMP	Blink	Blink
UVLO or Other faults	Dark	Dark

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℃. This feature protects the UCT3146 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 UCT3146.

The conditions that cause the UCT3146 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:

$PD = (V_{CC} – V_{BAT}) • I_{BAT}$

Where PD is the power dissipated, V_{CC} is the input supply voltage, V_{BAT} is the battery voltage, I_{BAT} is the charge current. The approximate ambient temperature at which the thermal feedback begins to protect the IC is:

$T_A = 120℃ – PD•\theta_{JA}$

$T_A = 120℃ – (V_{CC} – V_{BAT}) • I_{BAT} •\theta_{JA}$

Reducing the voltage drop across the internal MOSFET can significantly decrease the power dissipation in the IC. This has the effect of increasing the current delivered to the battery during thermal regulation. One method is by dissipating some of the power through an external component, such as a resistor or diode. By dropping voltage across a resistor in series with a 5V wall adapter, the on-chip power dissipation can be decreased, thus increasing the thermally regulated charge current.

Under-voltage Lockout (UVLO)

An internal under voltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until VCC rises above the under voltage 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 V_{CC} rises 100mV above the battery voltage.

Battery Temperature Sense and Monitor

The UCT3146 has the temperature monitor function in order to protect the battery from damage due to over or under temperature. By connection the TEMP pin to a resistor divider and the NTC themistor inside the battery, the UCT3146 compares the voltage on the TEMP pin with the VLOW and VHIGH threshold voltages, and terminates the charge process while VTEMP beyond the threshold. VLOW is about 40% of VCC and VHIGH is about 80% of VCC.

The function is closed when TEMP is connected to GND or left floating.

Manual Shutdown

The UCT3146 can be manually shutdown by setting CE pin to LOW or by disconnecting the RPROG. Setting CE back to HIGH or reconnect the RPROG resumes the device.

Stability Consideration

The constant-voltage mode feedback loop is stable without an output capacitor provided a battery is connected to the charger output. With no battery present, an output capacitor is recommended to reduce ripple voltage. In constant current mode, the PROG pin is in the feedback loop, not the battery. The constant-current mode stability is affected by the impedance at the PROG pin. With no additional capacitance on the PROG pin, the charger is stable with the programming resistor value as high as 20k. However, additional capacitance on this node reduces the maximum allowed program resistor. The pole frequency at the PROG pin should be kept above 100kHz.

Enlarge the Charge Current

The resistor between external Power Supply Input and the VCC pin of the UCT3146(refer to the application circuit) is to enlarge the thermal regulated charge current. For example, at room temperature, the full charge current to a 3.75V Li-ion battery by directly powered from a 5V power supply (assuming θ_{JA} =125℃/W) is:

$$I_{BAT} = \frac{145 - 25}{(5 - 3.75) \times 125} = 768(mA)$$

While connecting a resistor(R_{CC}, 0.25Ω) from the power supply to the VCC pin, the full charge current comes to:

$$I_{BAT} = \frac{145 - 25}{(VCC - I_{BAT}R_{CC} - V_{BAT}) \times 125} = 948(mA)$$

External Component Selection Guide

- **Output Capacitors**

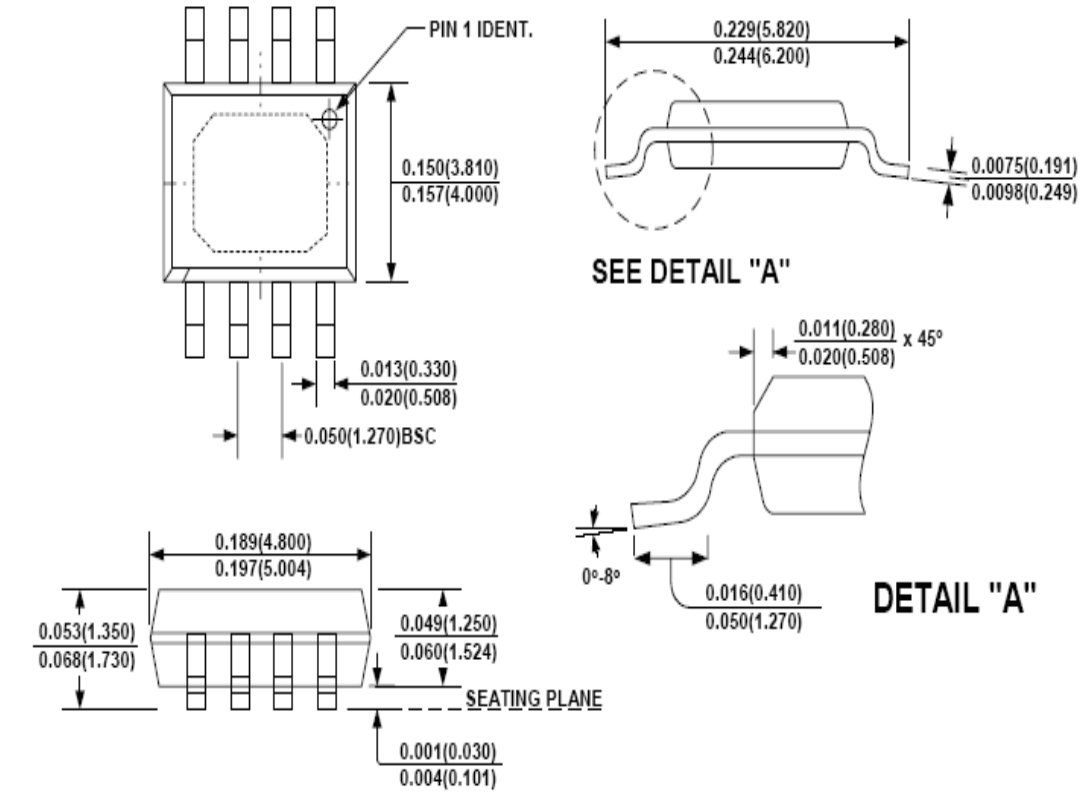
With no battery present, an output capacitor is recommended to reduce ripple voltage. When using high value, low ESR ceramic capacitors, it is recommended to add a 1Ω resistor in series with the capacitor. No series resistor is needed if tantalum capacitors are used.

- **Programmed resistor**

Use a resistor with 1% precision to increase the charging current accuracy.

PACKAGE OUTLINE

ESOP8



NOTE:
1) Control dimension is in inches. Dimension in bracket is millimeters.