HX4056C

1A Standalone Linear Li-Ion Battery Charger

Description

The HX4056C is a complete constant-current & constant-voltage linear charger for single cell lithium-ion batteries. Its PSOP8 package and low external component count make the HX4056C ideally suited for portable applications. Further more , the HX4056C can work within USB and wall adapter.

No blocking diode is required due to the internal PMOSFET architecture and have prevent to negative Charge Current Circuit. 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 or 4.35V, and the charge current can be programmed externally with a single resistor. The HX4056C automatically terminates the charge cycle when the charge current drops to 1/10th the programmed value after the final float voltage is reached.

HX4056C Other features include current monitor, under voltage lockout, automatic recharge and two status pin to indicate charge termination and the presence of an input voltage.

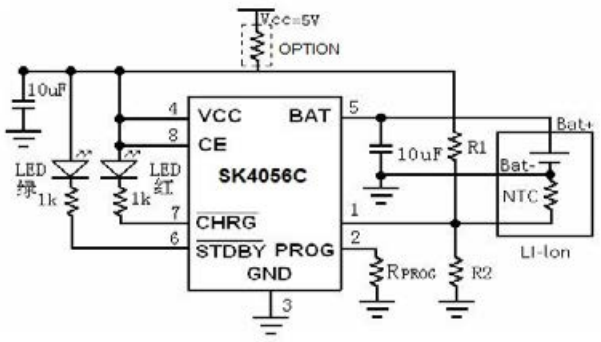
Features

- Programmable Charge Current Up to 1000mA
- Maximum Power Point Tracking (MPPT)
- No MOSFET, Sense Resistor or Blocking Diode Required
- Vin integrated for surge protection to 10V
- Complete Linear Charger in SOP-8 Package for Single Cell Lithium-Ion Batteries
- Constant-Current/Constant-Voltage
- Charges Single Cell Li-Ion Batteries Directly from USB Port
- Preset 4.2V or 4.35V Charge Voltage with 1.5% Accuracy
- Automatic Recharge
- Two Charge Status Output Pins
- C/10 Charge Termination
- 2.9V Trickle Charge Threshold
- Soft-Start Limits Inrush Current
- Available Radiator in PSOP8, SOT23-6,DFN2x2-6 Package, the Radiator need connect GND or impending

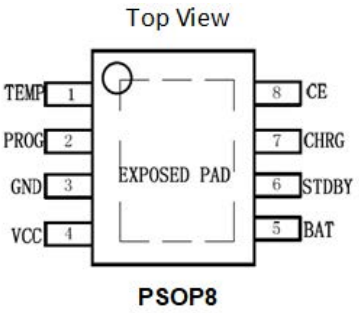
Application

- Charging Docks and Cradles
- Cellular Telephones, PDAs, GPS
- MP3、MP4 Player
- Digital Still Cameras, Portable Devices
- USB Bus-Powered Chargers, Chargers

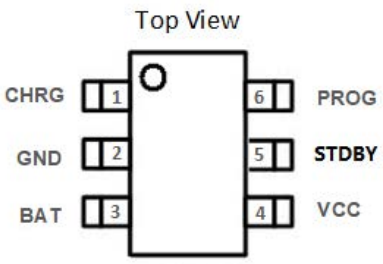
Typical Application



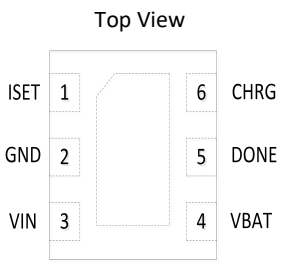
Pin Configuration



PSOP8



SOT23-6L



DFN2x2-6

Pin Description

Pin	PSOP8	SOT23-6	DFN2x2-6	Pin Function Description
TEMP	1			Connecting TEMP pin to NTC thermistor's output in Lithium ion battery pack. When Temp is tied to GND, this function is disabled. The other functions are normal.
PROG	2	6	1	Constant charge current setting and charge current monitor pin
GND	3	2	2	Ground pin
VCC	4	4	3	Input Voltage pin
BAT	5	3	4	Connect the positive terminal of the battery to BAT pin
STDBY	6	5	5	Open Drain Charge Status Output
CHRG	7	1	6	Open Drain Charge Status Output
CE	8			Chip Enable Input

Ordering Information

Part Number	Marking	Package	TAPE & REEL
HX4056CP8-42	S9018	PSOP8	4000/REEL
HX4056CP8-435	S9018	PSOP8	4000/REEL
HX4056CS6-42	018zH	SOT23-6	3000/REEL
HX4056CD6-42		DFN2x2-6	3000/REEL

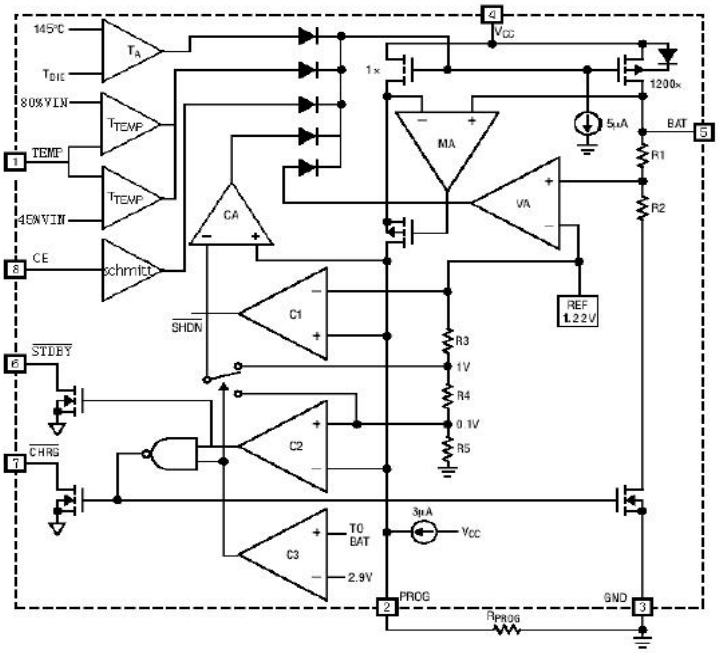
Absolute Maximum Rating

Parameter	Symbol	Value	Units
Input Supply Voltage	V_{in}	10	V
BAT Voltage	V_{BAT+}	7	V
TEMP/CE	V_{TEMP}	7	V
$\overline{CHRG}$/ $\overline{STDBY}$	V_{CHRG}	7	V
BAT Pin Current	I_{BAT}	1500	mA
PROG Pin Current	I_{PROG}	1500	uA
Maximum Junction Temperature		150	°C

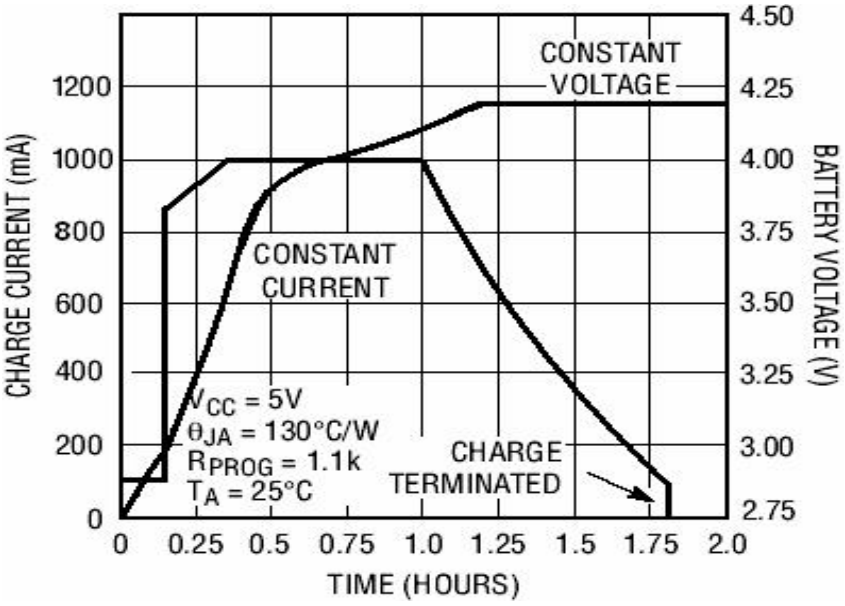
Operating Rating

Parameter	Value	Units
Junction Temperature	-20℃～85	°C
Storage Temperature	-40℃～125	°C
Lead Temperature (Soldering, 10 sec)	260±5	°C

Block Diagram



Typical Performance Characteristics



Complete Charge Cycle (1000mAh Battery)

Electrical Characteristics V_{IN} = 5V; T_J = 25°C; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CC}	Input Supply Voltage		4.0	5.0	7.0	V
I_{CC}	Input Supply Current	Charge Mode， R_{PROG}=2K		146		μA
		Standby Mode (Charge Terminated)		70		μA
		Shutdown Mode (R_{PROG} Not Connected, V_{CC} < V_{BAT}, or V_{CC} < V_{UV})		30		μA
V_{FLOAT}	Regulated Output Voltage	I_{BAT} = 30mA, R_{PROG}=10K	4.137	4.2	4.263	V
			4.282	4.35	4.415	V
I_{BAT}	BAT Pin Current	R_{PROG}=2K， Current Mode		560		mA
		R_{PROG}=1K， Current Mode		1120		mA
		Standby Mode V_{BAT}=4.3V		1		μA
		Shutdown Mode(R_{PROG} Not Connected)		1		μA
		Sleep Mode， V_{CC}=0V		0.1		μA
I_{TRIKL}	Trickle Charge Current	V_{BAT}<V_{TRIKL}， R_{PROG}=2K		60		mA
V_{TRIKL}	Trickle Charge Threshold Voltage	R_{PROG}=2K， V_{BAT} Rising		2.9		V
V_{TRHYS}	Trickle voltage hysteresis voltage	R_{PROG}=2K		100		mV
V_{UV}	V_{CC} Under voltage Lockout Threshold	From V_{CC} Low to High		3.7		V
V_{UVHYS}	V_{CC} Under voltage Lockout Hysteresis			150		mV
V_{ASD}	V_{CC} – V_{BAT} Lockout Threshold Voltage	PROG Pin Rising		150		mV
		PROG Pin Falling		100		mV
I_{TERM}	C/10 Termination Current Threshold	R_{PROG}=2K R_{PROG}=1K		60 100		mA mA
V_{PROG}	PROG Pin Voltage	R_{PROG}=2K， Current Mode		1.0		V
$I_{\overline{CHRG}}$	$\overline{CHRG}$ Pin Weak Pull-Down Current	$I_{\overline{CHRG}}$ = 5mA			0.4	V
$V_{\overline{STDBY}}$	$\overline{STDBY}$ Pin Output Low Voltage	$I_{\overline{STDBY}}$ =5mA			0.4	V
V_{TEMP-H}	TEMP pin voltage of the high-end flip			80		%Vcc
V_{TEMP-L}	TEMP pin voltage of the low-end flip			45		%Vcc
ΔV_{RECHRG}	Recharge Battery Threshold Voltage	V_{FLOAT} - V_{RECHRG}		150		mV
T_{LIM}	Thermal Protection Temperature			120		°C
R_{ON}	Power FET ON Resistance			550		mΩ
tss	Soft-Start Time	I_{BAT}=0 to 1120V/R_{PROG}		20		μs
$t_{RECHARGE}$	Recharge Comparator Filter Time	V_{BAT} High to Low		1		ms
t_{TERM}	Termination Comparator Filter Time	I_{BAT} Falling Below I_{CHG}/10		1		ms
Vmppt	Maximum Power Point Tracking Voltage			4.4		V
I_{PROG}	PROG Pin Pull-Up Current			0.5		μA

Applications

The HX4056C is a complete constant –current & constant-voltage linear charger for single cell lithium-ion batteries. Constant-current & constant -voltage to charger batter by internal MOSFET .It can deliver up to 1A of charge current .No blocking diode or external current sense resistor is required.

HX4056C include two Open-Drain charge status Pins: Charge status indicator and battery failure status output .The internal thermal regulation circuit reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 145℃. This feature protects the HX4056C 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 HX4056C or the external components. Another benefit of adopting thermal regulation is that charge current can be set according to typical, not worst-case, ambient temperatures for a given application with the assurance that the charger will automatically reduce the current in worst-case conditions.

The charge cycle begins when the voltage at the V_{CC} pin rises above the UVLO level, a current set resistor is connected from the PROG pin to ground, and the CE pin is pulled above the chip enable threshold. The $\overline{CHRG}$ pin outputs a logic low to indicate that the charge cycle is on going. At the beginning of the charge cycle, if the battery voltage is below 2.9V, the charge is in recharge mode to bring the cell voltage up to a safe level for charging. The charger goes into the fast charge constant-current mode once the voltage on the BAT pin rises above 2.9V. In constant current mode, the charge current is set by R_{PROG}.

When the battery approaches the regulation voltage 4.2V, the charge current begins to decrease as the HX4056C enters the constant-voltage mode. When the current drops to charge termination threshold, the charge cycle is terminated, and $\overline{CHRG}$ pin assumes a high impedance state to indicate that the charge cycle is terminated and $\overline{STDBY}$ pin is pulled low. The charge termination threshold is 10% of the current in constant current mode. To restart the charge cycle, remove the input voltage and reapply it, or momentarily force CE pin to 0V. The charge cycle can also be automatically restarted if the BAT pin voltage falls below the recharge threshold. The on-chip reference voltage, error amplifier and the resistor divider provide regulation voltage with 1% accuracy which can meet the requirement of lithium-ion and lithium polymer batteries. When the input voltage is not present, or input voltage is below V_{BAT}, the charger goes into a sleep mode, dropping battery drain current to less than 3μA. This greatly reduces the current drain on the battery and increases the standby time. The charger can be shutdown by forcing the CE pin to GND.

Programming charge current

The charge current is programmed using a single resistor from the PROG pin to ground. The program resistor and the charge current are calculated using the following equations:

$$R_{PROG} = 1120/I_{BAT} (\text{error}\pm 10\%)$$

In application, according the charge current to determine R_{PROG} ,the relation between R_{PROG} and charge current can reference the following chart:

R_{PROG} (k)	I_{BAT} (mA)
28	40
18.6	60
9.3	120
4.6	240
3.73	300
2.8	400
1.86	600
1.55	720
1.4	800
1.24	900
1.12	1000

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 t_{TEMP} (typically 1.8mS), Charging is terminated. The charge current is latched off and the HX4056C enters standby mode, where the input supply current drops to 55μA (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 1.8mS filter time (t_{TEMP}) 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 HX4056C terminated 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 HX4056C constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the 4.02V 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 or the charger must be shut down and restarted using the PROG pin. Figure 1 shows the state diagram of a typical charge cycle.

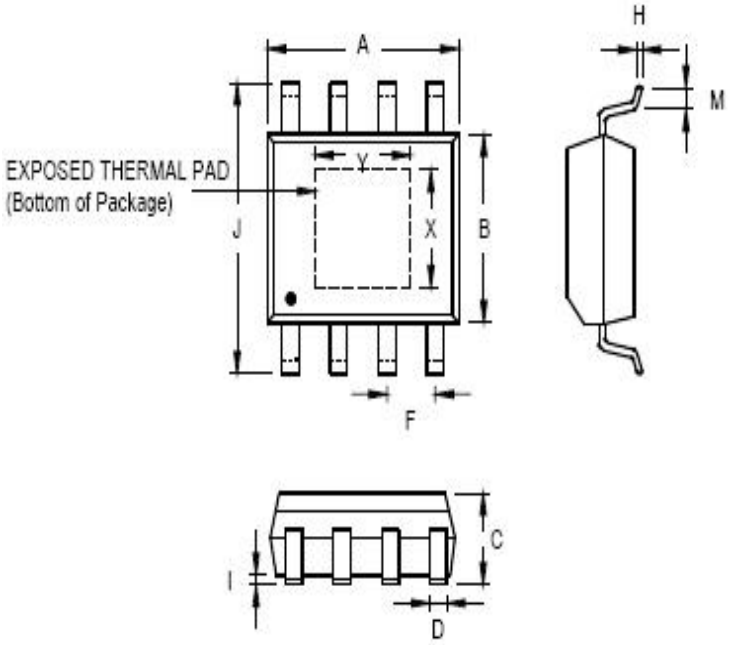
Charge status indicator

HX4056C has two open-drain status indicator output $\overline{CHRG}$ and $\overline{STDBY}$. $\overline{CHRG}$ is pull-down when the HX4056C in a charge cycle. In other status $\overline{CHRG}$ in high impedance. $\overline{CHRG}$ and STDBY are all in high impedance when the battery out of the normal temperature.

Represent in failure state, when TEMP pin in typical connecting, or the charger with no battery: red LED and green LED all don't light. The battery temperature sense function is disabled by connecting $\overline{TEMP}$ pin to GND. If battery is not connected to charger, CHRG pin outputs a PWM wave to, the frequency of CHRG flicker about 1-4S, If not use status indicator should set status indicator output connected to GND.

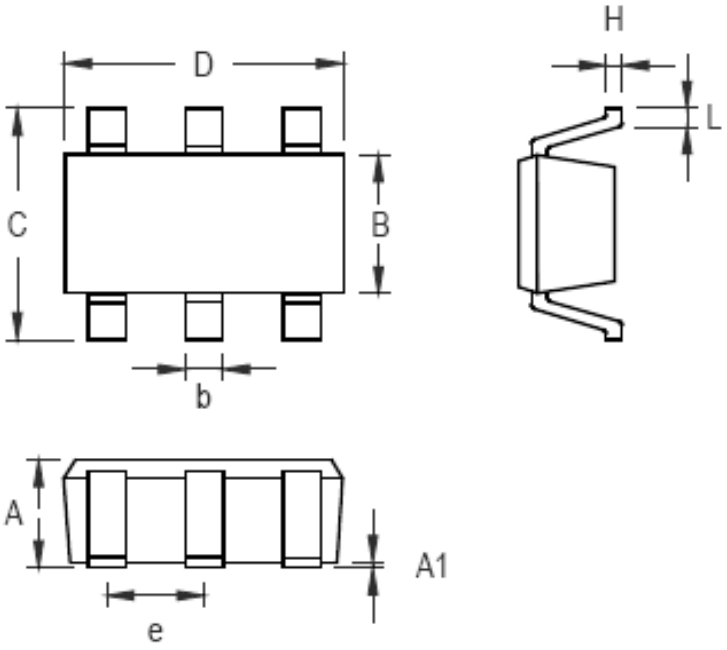
charger's status	Red led	Green led
Charging	light	dark
Battery in full state	dark	light
Under-voltage, battery's temperature is to high or too low, or not connect to battery (use TEMP)	dark	dark
BAT pin is connected to 10uF capacitor, No battery mode(TEMP=GND)	Green LED bright, Red LED flicker F=1-4 S	

OUTLINE DRAWING PSOP8



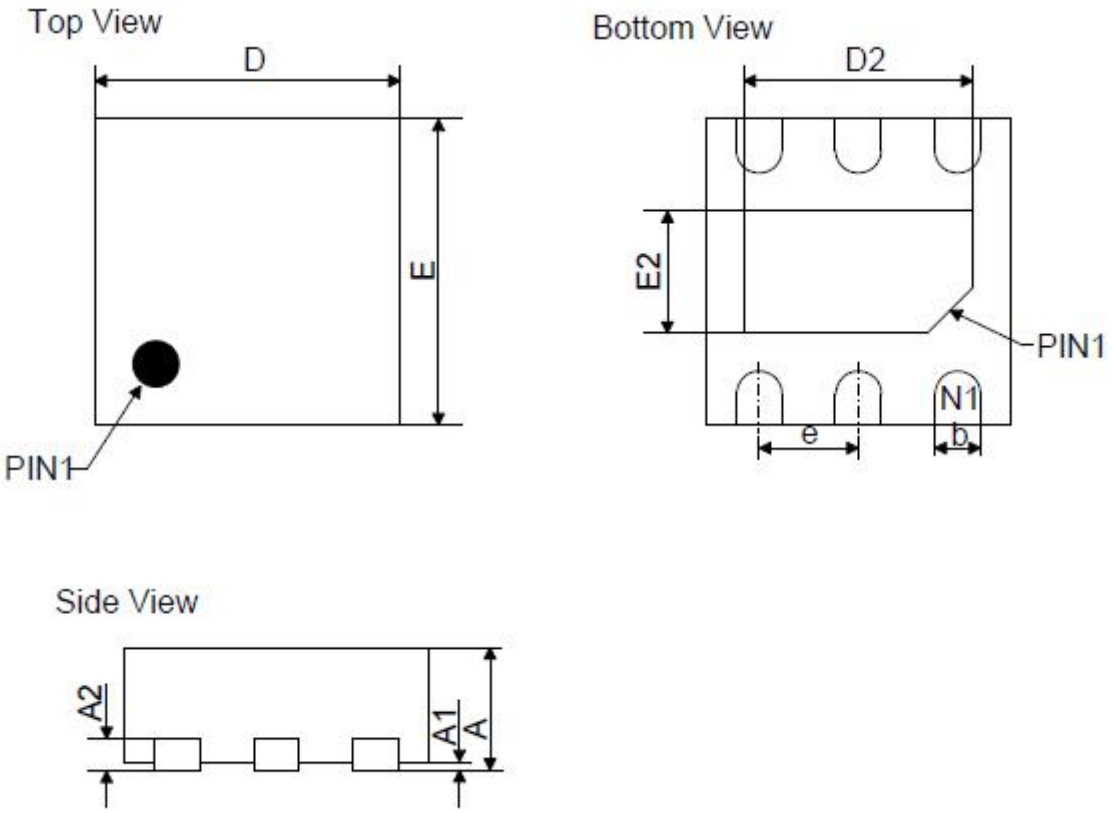
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	4.801	5.004	0.189	0.197
B	3.810	3.988	0.150	0.157
C	1.346	1.753	0.053	0.069
D	0.330	0.508	0.013	0.020
F	1.194	1.346	0.047	0.053
H	0.191	0.254	0.008	0.010
I	0.000	0.152	0.000	0.006
J	5.791	6.198	0.228	0.244
M	0.406	1.270	0.016	0.050
X	2.057	2.515	0.081	0.099
Y	2.057	3.404	0.081	0.134

OUTLINE DRAWING SOT23-6



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.889	1.295	0.031	0.051
A1	0.000	0.152	0.000	0.006
B	1.397	1.803	0.055	0.071
b	0.250	0.560	0.010	0.022
C	2.591	2.997	0.102	0.118
D	2.692	3.099	0.106	0.122
e	0.838	1.041	0.033	0.041
H	0.080	0.254	0.003	0.010
L	0.300	0.610	0.012	0.024

OUTLINE DRAWING DFN 2x2-6



COMMON DIMENSIONS (MM)			
REF	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	-	0.05
A2		0.2 REF	
D	1.95	2.00	2.05
E	1.95	2.00	2.05
D2	1.35	1.50	1.60
E2	0.65	0.80	0.90
L	0.25	0.35	0.45
b	0.25	0.30	0.35
e		0.65 Bsc	