0.8A Standalone Linear Li-Ion Battery Charge TP4056V VER V1-1

General Description

The TP4056 is a complete constant-current/constant-voltage linear charger for single cell lithium-ion batteries. Its ESOP8 package and low external component count make the TP4056 ideally suited for portable applications. Furthermore, the TP4056 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 TP4056 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 TP4056 automatically enters a low current CHRGe, dropping the battery drain current to less than 1μA. Other features include charge current monitor, automatic recharge and a CHRGus pin to indicate charge termination and the presence of an input voltage.

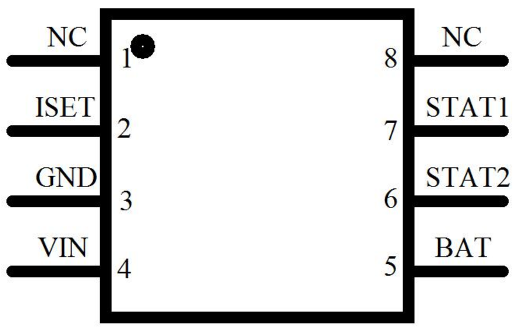
Features

- Programmable Charge Current Up to 800mA
- No MOSFET, Sense Resistor or Blocking Diode Required
- Complete Linear Charger in ESOP8 Package for Single Cell Lithium-ion Batteries
- Constant-Current/Constant-Voltage Operation with Thermal Regulation to Maximize
- Charge Rate Without Risk of Overheating
- 4.2V Charge Voltage with ± 1% Accuracy
- Charge Current Monitor Output for Gas Gauging
- Automatic Recharge
- 2.9V Trickle Charge Threshold
- C/10 Charge Termination
- Output OCP
- Charging OTP

Applications

- Portable Media Players/MP3 players
- Cellular and Smart mobile phone
- PDA/DSC
- Bluetooth Applications

Functional Pin



ESOP8

PIN	PIN Number	DESCRIPTION
1	NC	No Connector
2	ISET	Charge Current Program, Charge Current Monitor and Shutdown Pin.The charge current is programmed by connecting a 1% resistor(RPROG)to ground.When charging in constant-current mode,this pin servos to 1V. In all modes, the voltage on this pin can be used to measure the charge current using the following formula: ISET=1000/RPROG.
3	GND	Ground
4	VIN	VIN is the input power source. Connect to a wall adapter.
5	BAT	BAT is the connection to the battery. Typically a 10μF Tantalum capacitor is needed for stability when there is no battery attached. When a battery is attached, only a 0.1μF ceramic capacitor is required.
6	STAT2	Open-Drain Charge Status Output.When the battery is charging, the STAT pin could be pulled High by an external pull high resistor. When the charge cycle is completed, the pin is pulled Low by an internal N-channel MOSFET.
7	STAT1	Open-Drain Charge Status Output.When the battery is charging, the STAT pin is pulled low by an internal N-channel MOSFET. When the charge cycle is completed, the pin could be pulled High by an external pull high resistor.
8	NC	No Connector

Absolute Maximum Ratings (Note 1;2)

Input to GND(VCC) -- -0.3V to 8V
Other Pin to GND-- -0.3V to 6V
BAT Short-circuit Duration-- Continuous
Maximum Junction Temperature -- 125°C
Operating Junction Temperature Range (TJ) -- -20℃ to 85°C
Maximum Soldering Temperature (at leads, 10 sec) -- 260°C
HBM(Human Body Mode)-- 2KV
MM(Machine Mode)-- 200V

Note 1. 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.

Note 2. Devices are ESD sensitive. Handling precaution is recommended.

Thermal Information (Note 3)

Maximum Power Dissipation (ESOP8, PD,TA=25°C) -- 1.5W
Thermal Resistance (ESOP8, JA) -- 65℃/W

Note 3. JA is measured in the natural convection at TA = 25 C on a high effective thermal conductivity four-layer test board of JEDEC 51-7 thermal measurement standard.

Electrical Characteristics(TA=25°C,VIN=5V, unless otherwise noted.)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
VCC	Adapter/USB Voltage Range		3.9	5	6	V
ICC	Input Supply Current	Charge Mode, RPROG=10k		300	1000	uA
		Standby Mode (Charge Terminated)		50	200	
		Shutdown Mode (VCC<VBAT,or VCC<VUV)		50	200	
VFLOAT	Regulated Output (Float) Voltage	0°C ≤TA ≤ 85°C	4.158	4.2	4.242	V
IBAT	BAT Pin Current	RPROG=10k, Current Mode	80	100	120	mA
		RPROG=2k, Current Mode	400	500	600	
		RPROG=NC, Current Mode		80		
		Standby Mode, VBAT= 4.2V Shutdown Mode (RPROG NC)	0		±1	uA
VTRIKL	Trickle Charge Threshold Voltage	RPROG=10k, VBAT Rising	2.8	2.9	3.0	V
VTRHYS	Trickle Charge Hysteresis Voltage	RPROG=10k		100		mV
ITRIKL	Trickle charge current	VBAT< VTRIKL Rprog=NC		32		mA
		VBAT< VTRIKL Rprog=10K		40		
		VBAT< VTRIKL Rprog=2K		200		
VUV	VCC Undervoltage Lockout Threshold	From VCC Low to High	3.7	3.8	3.9	V
VUVHYS	VCC Undervoltage Lockout Hysteresis		150	200	300	mV
VASD	VCC – VBAT Lockout Threshold Voltage			150		mV
VPROG	PROG Pin Voltage	RPROG=10k, Charge Mode		1		V
VCHRG	CHRG Pin Output Low Voltage	ICHRG=5mA			0.1	V
ΔVRECHRG	Recharge Battery Threshold Voltage	VFLOAT - VRECHRG	100	150	200	mV

Applications Information

The TP4056 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 ± 1%. The TP4056 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 three external components. Furthermore, the TP4056 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.

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 TP4056 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:

$$RPROG=1000*1V / ICHG$$

$$ICHG=1000V / RPROG$$

The charge current out of the BAT pin can be determined at any time by monitoring the PROG pin voltage using the following equation:IBAT=VPROG/RPROG×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 TTERM (typically 1ms), charging is terminated. The charge current is latched off and the TP4056 enters standby mode, where the input supply current drops to 200μA. 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 TP4056 terminates the charge cycle and ceases to provide any current through the BAT pin. In this CHRG, all loads on the BAT pin must be supplied by the battery. The TP4056 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.

Charge CHRGus Indicator (CHRG)

The charge CHRGus output has two different CHRGes: strong pull-down (~5mA) and high impedance. The strong pull-down CHRGe indicates that the TP4056 is in a charge cycle. Once the charge cycle has terminated, the pin CHRGe is determined by under voltage lockout conditions. High impedance indicates that the charge cycle complete or the TP4056 is in under voltage 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 two CHRGes.

Charge Termination

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 125℃. This feature protects the TP4056 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 TP4056. 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.

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 VCC raises 150mV above the battery voltage.

Automatic Recharge

Once the charge cycle is terminated, the TP4056 continuously monitors the voltage on the BAT pin using a comparator with a 2ms filter time (TRECHARGE). 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. CHRG output enters a strong pull-down CHRGe during recharge cycles.

Power Dissipation

The conditions that cause the TP4056 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=(VCC－VBAT) • IBAT

where PD is the power dissipated, VCC is the input supply voltage, VBAT is the battery voltage and IBAT is the charge current. The approximate ambient temperature at which the thermal feedback begins to protect the IC is:

$$TA=125℃-PD\theta JA$$

$$TA=125℃-(VCC-VBAT) \bullet IBAT \bullet \theta JA$$

Example: An TP4056 operating from a 5V USB supply is programmed to supply 800mA full-scale current to a discharged Li-Ion battery with a voltage of 3.75V. Assuming θ JA is 65 ℃ /W (see Board Layout Considerations), the ambient temperature at which the TP4056 will begin to reduce the charge current is approximately:

$$TA=125℃-(5V-3.75V)\cdot(800mA)\cdot 65℃/W$$

$$TA=125℃-1W\cdot 65℃/W=60℃$$

Moreover, when thermal feedback reduces the charge current, the voltage at the PROG pin is also reduced proportionally as discussed in the Operation section. It is important to remember that TP4056 applications do not need to be designed for worst-case thermal conditions since the IC will automatically reduce power dissipation when the junction temperature reaches approximately 125℃.

VCC Bypass Capacitor

Many types of capacitors can be used for input bypassing; however, caution must be exercised when using multilayer ceramic capacitors. Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, high voltage transients can be generated under some start-up conditions, such as connecting the charger input to a live power source.Adding a 1.5Ω resistor in series with an X5R ceramic capacitor will minimize start-up voltage transients.

Layout Considerations

For the main current paths as indicated in bold lines, keep their traces short and wide.
Put the input capacitor as close as possible to the device pins (VCC and GND).
Connect all analog grounds to a command node and then connect the command node to the power ground behind the output capacitors.

Packaging Information