Nanjing Tuopin Microelectronics Co., Ltd.

NanJing Top Power ASIC Corp.

Data Sheet

DATASHEET

TP5400

(1A lithium battery charging and 5V/1A boost control chip)

describe

TP5400 is a single-cell lithium-ion battery charger and constant 5V boost controller for mobile power.

The part integrates high-precision voltage and charging current regulator, pre-charging, charging status indication and charging cutoff functions, and can output a maximum charging current of 1A. The boost circuit adopts a VFM switching DC/DC boost converter with extremely low no-load current manufactured by CMOS technology. It has extremely low no-load power consumption (less than 10uA), and the boost output driving current capability can reach 1A. No external

buttons are required, and it can be plug-and-play. The charging part is a linear step-down method with a built-in PMOSFET and an anti-backflow circuit, so no external detection resistor and isolation diode are required. Thermal feedback can automatically adjust the charging current to limit the chip temperature under high-power operation or high ambient temperature conditions, and the full voltage is fixed at 4.2V. The charging current can be set externally through a resistor. When the battery reaches 4.2V, the charging current gradually decreases to 1/5 of the set current value, and the TP5400 will automatically terminate the charging. The boost part also has a built-in power NMOSFET, and the smaller internal resistance can provide a driving capability of up to 5V/1A. The high integration level enables the TP5400 to work normally with only a small number of peripheral devices. The TP5400 also integrates charging temperature protection and boost input power current limiting loop, which can dynamically adjust the current according to the load conditions, and has fast response and over-current shutdown functions. The boost converter adopts variable frequency, so it has extremely low no-load power consumption, ripple, stronger driving ability, and

Features ÿProgrammable charging current with a typical value of up to 1000mA,

and a maximum of 1.2A; ÿUp to 1A boost output current (Vbat=3.3V), with a maximum output of 1.5A (Vbat=3.8v);

ÿAutomatic frequency adjustment (VFM) to adapt to different boost loads (5V no-load standby current is less than 10uA), no need to press a button to start the low battery voltage (less than 3V) to automatically stop the boost; ·Special circuit for single-cell lithium-ion battery mobile power supply; ·High boost efficiency: 88% (Typ), maximum 90%; ·Constant current/constant voltage operation, and has a thermal regulation function that can maximize the charging rate without the risk of overheating;

·4.2V preset charge voltage with ±1% accuracy ·5V preset boost accuracy with ±2.5% accuracy ·Up to 9V input ·2 charge status indicators: open-drain output drives LED ·C/5 charge termination current ·C/5 trickle charge below 2.9V

·Charge soft-start reduces inrush current ·No MOSFET, sense resistor or isolation diode required ·8-pin ESOP thermally enhanced package.

Application

·Mobile power·Portable devices

Absolute maximum

ratings Input power voltage (VCC): -0.3V to 10V PROG: -0.3V to VCC+0.3V

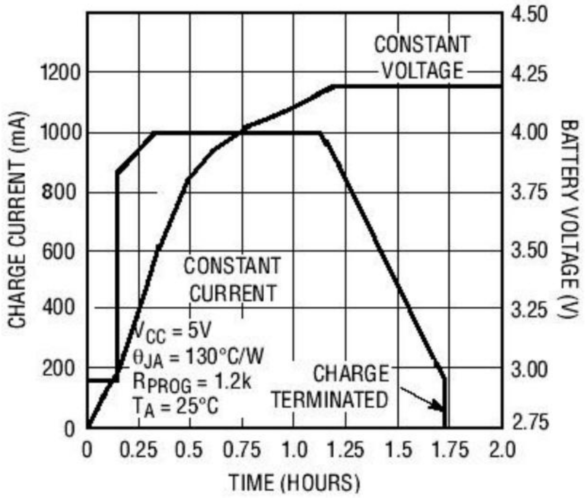
BAT: 0Vÿ7V

·LX: -2Vÿ10V ·VOUT: -0.3Vÿ10V

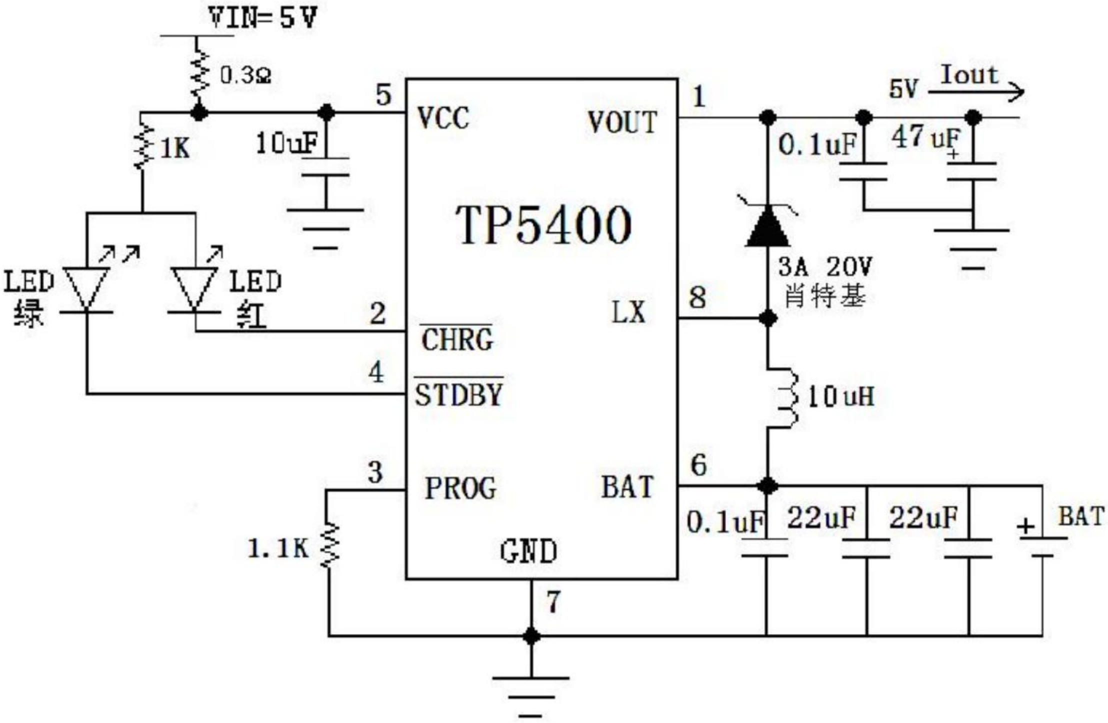
·CHRG : -0.3Vÿ10V ·BAT short circuit duration: continuous ·BAT pin current: 1200mA ·Boost maximum output current 1.8A/5V

·Maximum junction temperature: 145ÿ ·Operating ambient temperature range: -40ÿÿ85ÿ ·Storage temperature range: -65ÿÿ125ÿ ·Pin temperature (soldering time 10 seconds): 2

Full charge cycle (1000mAh battery)

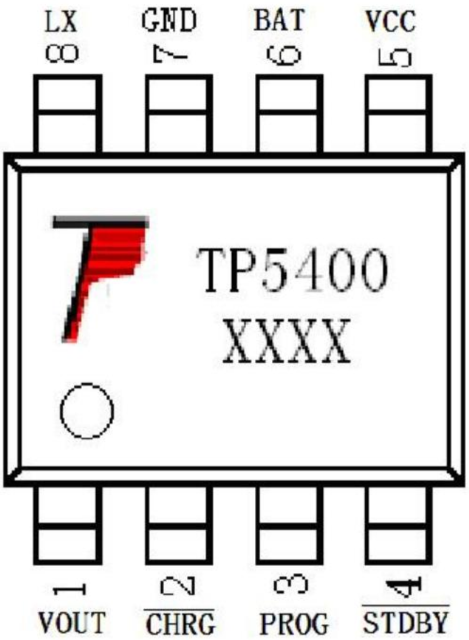


typical application



Single Cell Li-Ion Battery Charger 1A and Boost 5V Output 1A Controller

Packaging/Ordering Information

<table>
<tr><td rowspan="6">

8-pin ESOP package (with heat sink on the bottom
The heat sink is recommended to be grounded)
XXXX is the production date (year.week)</td><td>Order Model</td></tr>
<tr><td>TP5400-ESOP8</td></tr>
<tr><td>Device marking</td></tr>
<tr><td>TP5400</td></tr>
<tr><td>Physical picture</td></tr>
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Electrical properties

Note • in the table indicates that the indicator is suitable for the entire operating temperature range, otherwise it only refers to TA=25ÿ, VCC=5V unless otherwise specified.

symbol	parameter	condition		Min	Typ	Max	Unit
VCC	Input power voltage		•	4.0	5	9.0	V
ICC	Input power current	Charging mode, RPROG=10K	•		150	500	ÿA
		Standby mode (charge termination)	•		40	100	ÿA
		Stop mode (RPROG not connected,	•		40	100	ÿA
		VCC < VBAT, or VCC < VUV)			40	100	ÿA
		Boost start			0		ÿA
VFLOAL	stable output (floating charge) voltage	0ÿÿTAÿ85ÿ, IBAT=40mA		4.158	4.2	4.242	V
IBAT	BAT pin current (Except for instructions, Vbat=4.0v)	RPROG=1.5K, charging mode	•	700	740	800	mA
		RPROG=1.1K, charging mode	•	950	1000	1050	mA
		Boost without load, VBAT=3.8V	•		-10	-100	ÿA
ITRIKL	Trickle charge current	VBAT<VTRIKL, RPROG=1.5K	•	150	200	250	mA
VTRIKL	Trickle charge threshold voltage	RPROG = 1.5K, VBAT rises		2.8	2.9	3.0	V
VUV	VCC undervoltage lockout threshold	from VCC	•	3.4	3.6	3.8	V
ITERM	low to high C/5 Termination current threshold	RPROG = 1.5K	•	150	200	250	mA
VPROG	PROG pin voltage	RPROG = 1.5K, charging mode	•	0.9	1.0	1.1	V
VCHRG	$\overline{\text{CHRG}}$ pin output low voltage	$I_{\overline{CHG}}$ =5mA			0.3	0.6	V
VSTDBY	$\overline{\text{STDBY}}$ Pin output low level	$I_{\overline{STDBY}}$ =5mA			0.3	0.6	V
ÿVRECHRG	recharge battery threshold voltage	VFLOAT-VRECHRG		100	150	200	mV
	The junction temperature charging MOS tube				120		ÿ
	"turns on" in the TLIM limited temperature mode						
Charging RON	Resistance (between VCC and BAT)				450		mÿ
tss	soft start time	IBAT = 0 to IBAT = 1200V/RPROG			20		us
tTERM	terminates the comparator filter time	IBAT to fall below ICHG/5		0.8	1.8	4	ms
VOUT	boost output 5V	Load resistance		4.875	5	5.125	V
VBatLOW	battery undervoltage protection	RL=1k Vbat drops	•	2.9	3	3.1	V
VBatHigh	battery undervoltage protection unlock	from 3.6V Vbat rises from 2.7V	•	3.2	3.3	3.4	V
FOSC	oscillator frequency			300	400	500	KZN
ÿBoost	Boost efficiency	VBAT=3.8V IOUT=500mA			90		%
ÿBoost	Boost efficiency	VBAT=3.8V IOUT=1000mA			88		%
Dty	Maximum duty cycle				75		%
Boost RON	Boost NMOS Internal resistance	VLX=0.4V			120		mÿ
ILxleak	boost NMOS tube leakage current	VLX=6V				1	uA
Ilmt_nmos	boost switch current limiting				4	4.5	A

Pin Function

VOUT (Pin 1): Output voltage detection pin. Connect to the boost 5V output terminal.

CHRG (Pin 2): Charging status indicator terminal of open-drain output during charging. When the charger is charging the battery, the CHRG pin is pulled to a low level by the internal switch, indicating that charging is in progress; otherwise, the CHRG pin is in a high impedance state.

PROG (Pin 3): Charge current setting, charge current monitoring and shutdown pin. Connecting a 1% precision resistor RPROG between this pin and ground can set the charge current. When charging in constant current mode, the voltage of the pin is maintained at 1V.

The PROG pin can also be used to shut down the charger. Disconnecting the set resistor to ground causes an internal 2.5ÿA current to pull the PROG pin high. When the voltage on this pin reaches the shutdown threshold voltage of 2.7V, the charger enters shutdown mode, charging stops, and the input supply current drops to 40ÿA. Reconnecting RPROG to ground causes the charger to shut down.

Resume normal operation.

STDBY (pin 4): Battery charging completion indication terminal. When the battery is fully charged, STDBY is pulled low by the internal switch, indicating that charging is complete. In addition, the STDBY pin will be in a high impedance state.

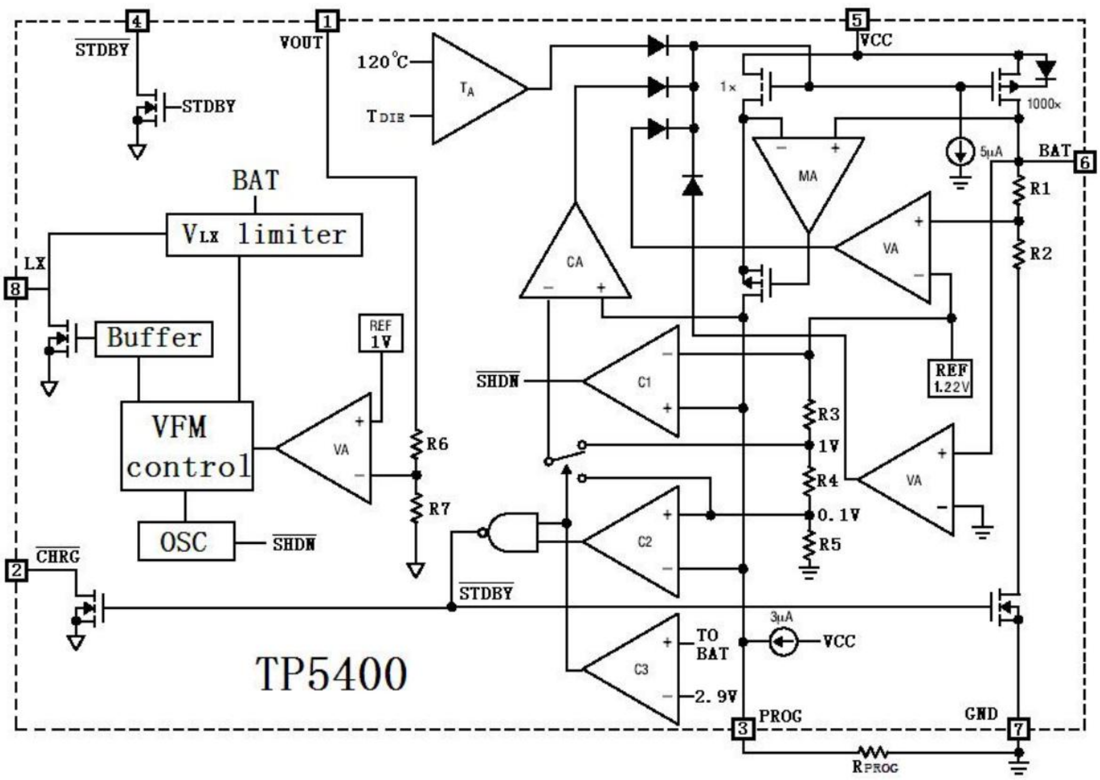
VCC (Pin 5): Charger Input Supply Voltage. Charge input supply pin. Typical value is 5V and should be bypassed with at least a 10ÿF capacitor. When VCC drops to When the BAT pin voltage is within 30mV, the TP5400 charging part enters shutdown mode and boosts the voltage to reduce IBAT to below 10ÿA.

BAT (Pin 6): Charging current output. This pin provides the battery The charging current is then adjusted to 4.2V.

A precision internal resistor divider sets the float charge voltage.

In the formula, the internal resistor divider is disconnected and the internal working state is in boost mode. power supply.

GND (Pin 7): Ground LX (Pin 8): Output end of the power tube inside the boost circuit.



working principle

TP5400 is a constant current/constant voltage A single-cell lithium-ion battery charging and boost discharge controller. It can provide 1000mA charging current (with a well-designed PCB layout). The boost circuit has a built-in NMOS power tube, and only an inductor, a Schottky diode and a small amount of capacitor are required to complete the 5V boost output.

When the VOUT terminal is connected to a load, the TP5400 can provide A 5V regulated voltage source with a driving capability of 1A.

Charging Cycle

When the Vcc pin voltage rises above the UVLO threshold level and a setting resistor is connected between the PROG pin and ground and when a battery is connected to the charger output, a charging cycle begins. If the BAT pin level is lower than 2.9V, the charger enters the trickle pre-charge mode. In this mode, the TP5400 provides a constant current current of 1/5 of the set charging current to increase the current voltage to a safe level, thereby achieving full current charging.

When the BAT pin voltage rises above 2.9V, the charger enters constant current mode, providing a constant charging current to the battery. When the BAT pin voltage reaches the final floating charge voltage (4.2V), the TP5400 enters constant voltage mode and the charging current begins to decrease. When the charging current drops to 1/5 of

the set value, the charging cycle ends. Charging current setting

The charge current is set by a resistor connected between the PROG pin and ground. The following approximate formula is used to calculate the resistor value according to the required charge current:

formula: $$R_{PROG} = \frac{1100}{I_{BAT}}$$

In customer applications, the relationship between RPROG and charging current can be determined by referring to the following table:

RPROG (ÿ)	IBAT
10k	130mA
5k	245mA
2k	560mA
1.5k	740mA
1.1k	1000mA

Charge Termination

The charge cycle is terminated when the charge current drops to 1/5 of the set value after reaching the final float voltage. This condition is detected by monitoring the PROG pin with an internal filter comparator. When the PROG pin voltage drops below 200mV for more than t_{TERM} (typically 1.8ms), charging is terminated. The charge current is latched off and the TP5400 enters standby mode, where the input supply current drops to 40ÿA. (Note: C/5 termination is invalid in trickle charge and thermal limit modes). While

charging, transient loads on the BAT pin can cause the PROG pin voltage to drop below 200mV briefly between the DC charge current dropping to 1/5 of the set value. The 1.8ms filter termination comparator ensures that t_{TERM} time on the transient loads of this nature do not cause the charge cycle to terminate prematurely. Once the average charge current drops below 1/5 of the set value, the TP5400 terminates the charge cycle and stops providing any current through the BAT pin. In this state, all loads on the BAT pin must be powered by the battery.

In standby mode, the TP5400 continuously monitors the BAT pin voltage. If the pin voltage drops below the recharge threshold (V_{RECHRG}) of 4.1V, another charging cycle begins and current is supplied to the battery again. When manually restarting the charging cycle in standby mode, the input voltage must be removed and then reapplied, or the charger must be turned off and restarted using the PROG pin.

Charge Status Indicator ($\overline{CHRG}$ $\overline{STDBY}$)

TP5400 has two open-drain status indication outputs , $\overline{CHRG}$ and $\overline{STDBY}$. When the charger is in the charging state, $\overline{CHRG}$ is pulled to a low level, and in other states , $\overline{CHRG}$ is in a high impedance state. When the battery is not connected to the charger, $\overline{CHRG}$ outputs a pulse signal to indicate that the battery is not installed. When the external capacitor of the battery connection terminal BAT pin is 10uF, the $\overline{CHRG}$ flashing period is about 0.5-2 seconds

When the status indication function is not used, connect the unused status indication output terminal to

the ground. The indicator light status can refer to the following table:

charging	red light CHG	Green Light STDBY
Charging state	On Off Off On	
Battery is fully	Flashing	On Off
charged No	Off	
battery state When boosting		

Charge Undervoltage Lockout

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 will keep the charger in shutdown mode. If the UVLO comparator is tripped, the charger will not exit shutdown mode until Vcc rises 50mV above the battery voltage. In the case of

charge lockout, the boost circuit automatically starts if the lithium battery voltage is above 3V.

Automatic restart

Once the charge cycle is terminated, the TP5400 immediately uses a comparator with a 1.8ms filter time ($t_{RECHARGE}$) to continuously monitor the voltage on the BAT pin. When the battery voltage drops below 4.1V (roughly corresponding to 80% to 90% of the battery capacity), the charge cycle restarts. This ensures that the battery is maintained at (or close to) a fully charged state and eliminates the need for periodic charge cycle starts. During the recharge cycle, the CHRG pin output re-enters a strong pull-down state and the STDBY pin output re-enters a high impedance state.

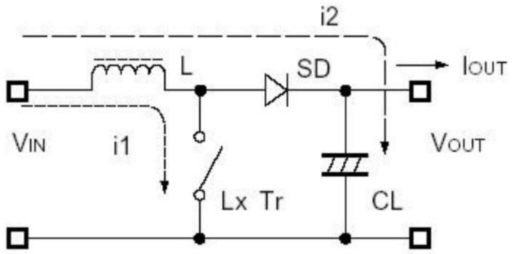
Charge current soft start

The TP5400 includes a

A soft-start circuit is used to minimize the inrush current when starting the power supply. When a charge cycle is initiated, the charge current will rise from 0 to the full-scale value in about 20mS. This can minimize the transient current load on the power supply during startup.

Boost discharge circuit

The boost circuit uses the energy storage of the inductor and the discharge effect of the inductor and the input power supply to obtain an output voltage higher than the input voltage. As shown in the figure below:



The boost circuit is not connected to the charging power supply and the lithium battery

When the battery voltage is between 3V and 4.2V, the boost circuit automatically starts and continuously outputs a 5V constant voltage source. In addition, when the BAT voltage is between 3V and 4.2V, and the input power supply Vcc is less than 3.8V, or Vcc<Vbat+50mV and the PROG terminal is suspended, the boost circuit will also work. The boost circuit has a lithium battery low voltage protection function. When the lithium battery voltage is as low as 3V, the TP5400 will automatically shut down the boost.

The boost circuit has an extremely low no-load current in the normal no-load standby state, and the average no-load current is less than about 10uA. This ensures that the lithium battery can still effectively maintain its own power during a long period of no-load standby, extending the standby time of the mobile power system.

Automatic shutdown due to lithium battery undervoltage

The boost circuit has a lithium battery low voltage protection function. When the lithium battery voltage drops to 3V, the TP5400 will automatically shut down the boost. When the lithium battery recovers to above 3.3V, the shutdown state is canceled and the boost resumes.

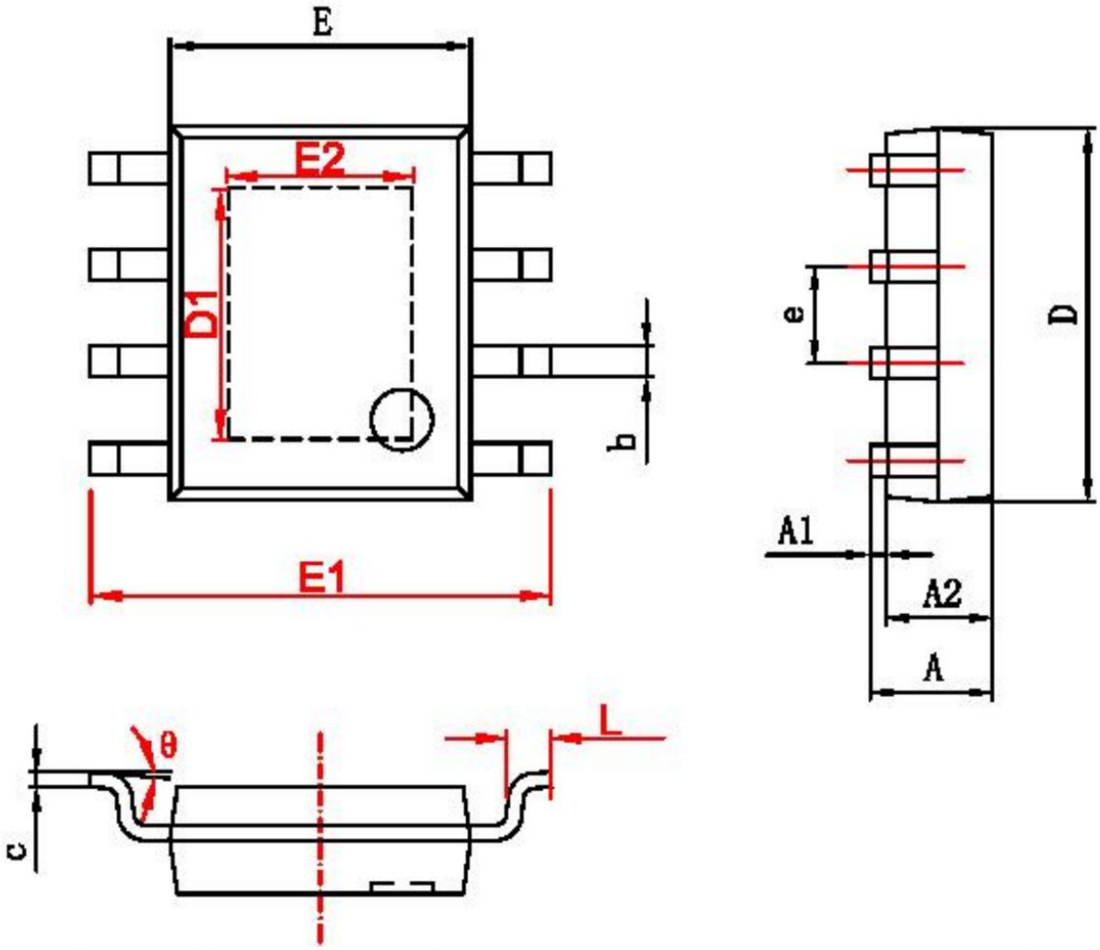
Heat sink connection and thermal

considerations Due to the small size of the ESOP8 package, poor heat dissipation in high current applications may cause the charging current to be reduced due to temperature protection. It is recommended that the heat sink at the bottom of the chip be connected to the PCB copper. The bottom heat sink can be grounded or left floating, and cannot be connected to other potentials. It is also important to use a thermally well-designed PC board layout to maximize the available charging current. The heat dissipation path used to dissipate the heat generated by the IC runs from the chip to the lead frame and reaches the PC board copper surface through the peak back leads (especially the ground lead). The PC board copper surface is a heat sink. The copper foil area connected to the pins should be as wide as possible and extend outward to a larger copper area to dissipate the heat to the surrounding environment. When designing the PC board layout, other heat sources on the board that are not related to the charger must also be considered because they will affect the overall temperatur

VCC bypass capacitor

There are many types of capacitors that can be used for input bypassing. However, caution must be exercised when using multilayer ceramic capacitors. Due to the self-resonance and package characteristics of some types of ceramic capacitors Due to the high Q value, high voltage transient signals may be generated under certain startup conditions (such as connecting the charger input to a working power supply). Electrolytic capacitors or tantalum capacitors are recommended.

8-pin ESOP package (unit: mm)



字符	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1. 350	1. 750	0. 053	0. 069
A1	0. 050	0. 150	0. 004	0. 010
A2	1. 350	1. 550	0. 053	0. 061
b	0. 330	0. 510	0. 013	0. 020
c	0. 170	0. 250	0. 006	0. 010
D	4. 700	5. 100	0. 185	0. 200
D1	3. 202	3. 402	0. 126	0. 134
E	3. 800	4. 000	0. 150	0. 157
E1	5. 800	6. 200	0. 228	0. 244
E2	2. 313	2. 513	0. 091	0. 099
e	1. 270 (BSC)		0. 050 (BSC)	
L	0. 400	1. 270	0. 016	0. 050
θ	0°	8°	0°	8°

TP5400 Test and Use Precautions

1. To ensure reliable use in various situations and prevent chip reliability degradation caused by spike and glitch voltages, it is recommended that the capacitors required for Vcc, BAT and VOUT in TP5400 applications be close to the chip pins, not too far away. At the same time, it is strongly recommended to connect a 0.1uF ceramic capacitor in parallel close to the pins.

2. It is recommended to use two 22uF capacitors in parallel for the BAT terminal capacitance value, and the VOUT terminal capacitance value should not be less than 47ÿF (too small capacitance value will cause unstable chip operation, and it is strongly required to use tantalum capacitors or electrolytic capacitors at the VOUT terminal), and it should have good frequency characteristics. In addition, since a spike voltage will be generated when the LX switch driving transistor is turned off, the voltage tolerance of the capacitor should be at least 3 times the designed output voltage.

3. Inductance value 3.3-22uH, 10uH is recommended. In addition, the DC impedance of the external inductor should be small, the capacitance value should be high, and it should not reach magnetic

saturation during operation. 4. The external diode should be a Schottky diode with a high switching speed, and SS32 is recommended.

5. This chip is designed to drive large loads, so the smaller the distance between the peripheral components and the chip, the better, and the shorter the connection, the better. In particular, the components connected to the VOUT terminal should minimize the length of the connection with the capacito

6. The GND terminal should be fully grounded, otherwise the zero potential inside the chip will change with the switching current, causing The working status is unstable.