南京拓品微电子有限公司

NanJing Top Power ASIC Corp.

TP5000

(2A switching 4.2V lithium battery / 3.6V LiFePO4 Charger)

Description

TP5000 is a switching buck single manganese lithium battery / LiFePO4 battery charge management chip. Its QFN16 ultra-compact package with simple peripheral circuit, making the TP5000 is ideal for portable equipment large current charging management applications. Meanwhile, TP5000 built-in input overcurrent, undervoltage protection, over temperature protection, short circuit protection, battery temperature monitoring, reverse battery protection.

TP5000 has a wide input voltage, divided into three stages Trickle pre-charge, constant current, constant voltage trickle charge the battery pre-charge current, constant current charging current adjusted through an external resistor, the maximum charging current of 2A. TP5000 switching frequency of 800kHz operating mode so that it can use smaller external components and smaller heat remains in the high current charging. TP5000 Built-power the PMOSFET, anti-intrusion circuit, so there is no need anti-intrusion perimeter protection Schottky diodes. TP5000 constant current function can also be used dry batteries in 2 strings of lithium batteries or 4 string input, constant current drive 0.5-7W white LED.

Characteristic

■ Single 4.2V lithium manganese or 3.6V LiFePO4 battery charge
■ Built-in power MOSFET, switching mode, The devices less heat, simple periphera
■Power adaptive function
■ programmable charge current, 0.1A--2A
■ programmable pre-charge current, 10% - 100%
■ eliminates the need for an external Schottky diode anti-intrusion
■ Wide operating voltage up to 9V
■ Two LED charge status indicator
■ chip temperature protection, overcurrent protection, undervoltage protection
■ battery temperature protection, reverse battery shutdown, short-circuit protection
■ switching frequency 800KHz, available inductor 2.2uH-10uH
■ automatic recharge function
■ less than 1% of the charging voltage control precision
■ paragraph Trickle, constant current, constant voltage charging to protect the battery
■ QFN16 4mm * 4mm ultra-small package

Absolute Maximum Ratings

■ input supply voltage (VIN):9V
■ BAT: 0V ~ 9V
■ BAT short duration: continuous
■ Maximum Junction Temperature: 145 °C
■ Operating ambient temperature range: -20 °C to 85 °C
■ Storage temperature range: -30 °C ~ 100 °C
■ Lead Temperature (Soldering, 10 sec): 260 °C
Application
■ portable devices, various chargers
■ smartphones, PDAs, mobile cellular phone
■ MP4, MP5 player, Tablet PC
■ miner's lamp
■ power tools
■ White LED Driver

Typical applications

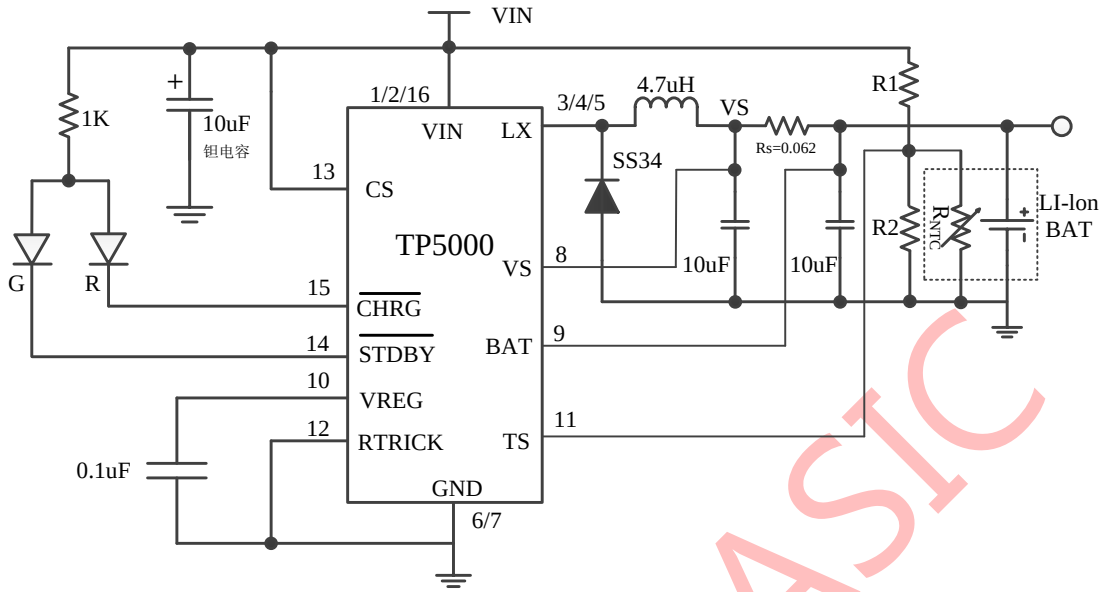


Figure 1 TP5000 4.2V lithium-ion battery charging 1.5A (150MA prefilled) Application Diagram

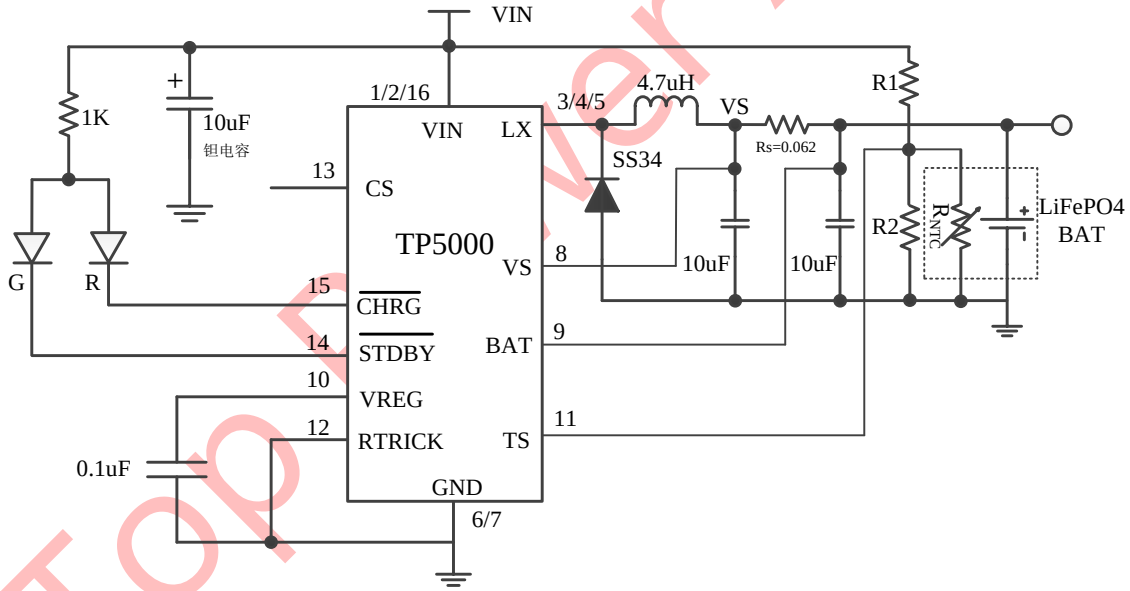
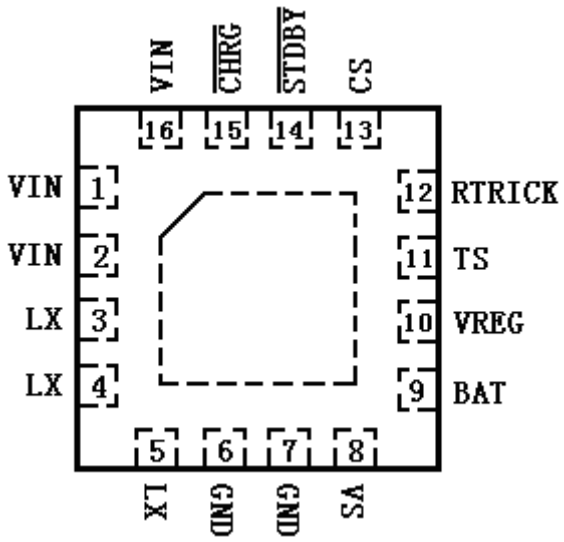


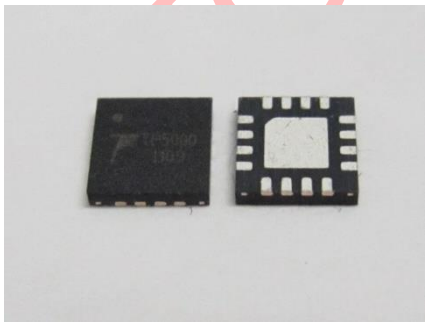
Figure 2 TP5000 3.6V LiFePO4 battery charging 1.5A (150MA prefilled) Application Diagram

Package / Ordering Information



16-pin 4mm * 4mm QFN 16 package top view
(Heat sink grounding can not be connected to other potential)

Orders Model
TP5000-QFN16
Device Marking
TP5000
Physical picture



TP5000 functional block diagram

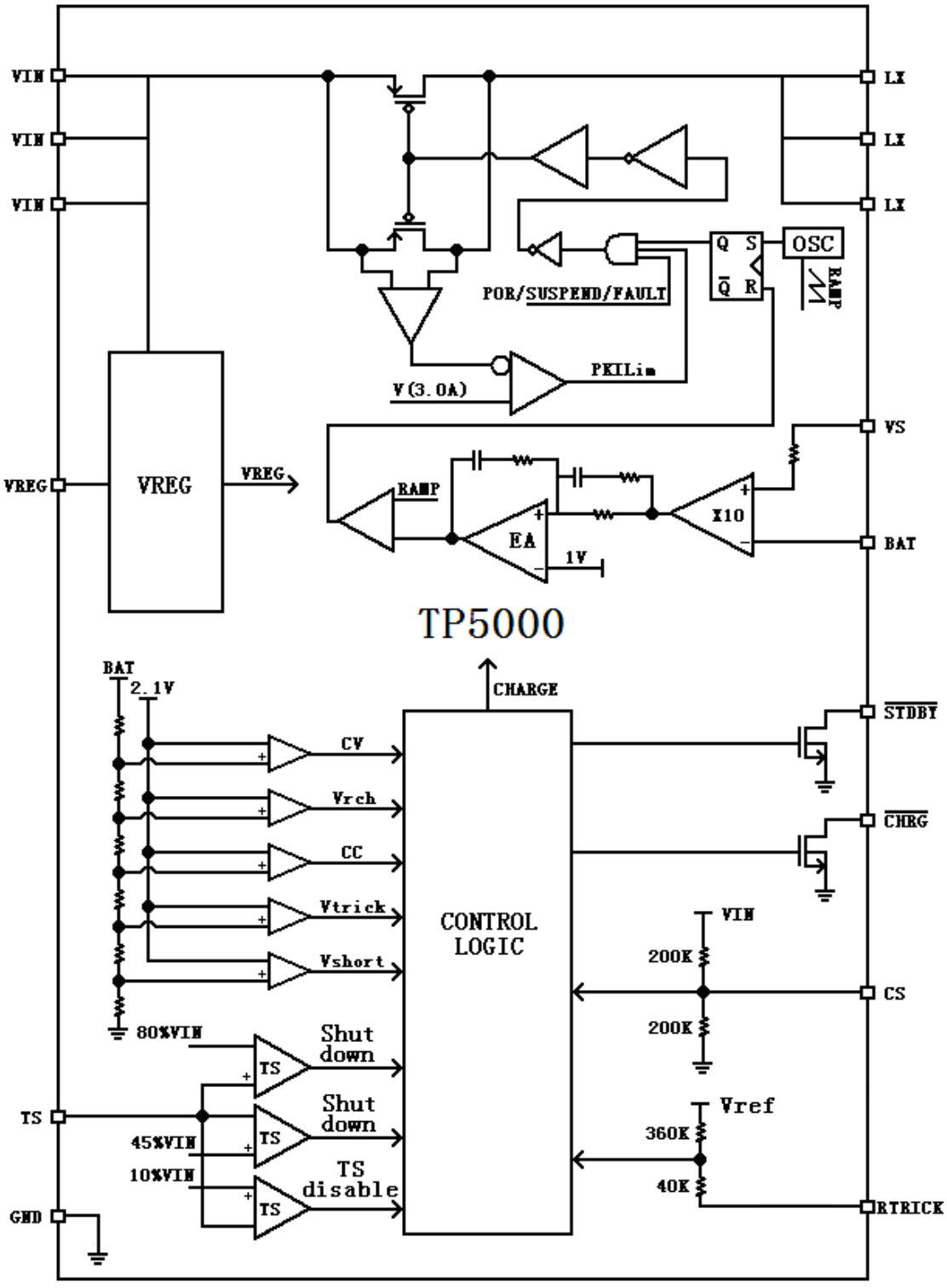


Figure 3 Functional block diagram of TP5000

Electrical characteristics

Table 1 TP5000 electrical characteristics of energy parameters

Where a sign ● denotes specifications which apply over the full operating temperature range, otherwise refers only to TRAR = 25 ° C. VIN = 5V, unless otherwise noted.

Symbol	Parameter	Condition		Min	Typ	Max	Unit
VIN	Input supply voltage		●	4.0	5	9.0	V
I_{CC}	Input supply current	Charge mode，RS=0.1Ω Standby mode (Charge termination) Shutdown mode （CS=GND，Vin<VBAT，or Vin<VUV）	● ● ●		250 180 180 180	500 250 250 250	μA μA μA μA
V_{FLOAL}	Charge cut-off voltage	4.2V Lithium ion battery		4.158	4.2	4.242	V
		3.6V LiFePO4 battery		3.564	3.6	3.636	V
I_{BAT}	BAT Pin Current: (Current-mode test conditions CS=VIN 、Battery voltage=3.8V)	RS=0.1Ω， Constant current mode, RS=0.062Ω，Constant current mode, Standby mode，V_{BAT}=4.2V, VIN=0V ，V_{BAT}=4.2V	● ● ● ●	800 1300 0 0	950 1530 −4 −4	1100 1760 −6 −6	mA mA uA uA
I_{TRIKL}	Trickle pre-charge current R_{TRICK} Pin to ground	1.2V<VBAT< VTRIKL ，RS=0.062	●	100	153	200	mA
F	Oscillation Frequency			650	800	950	KHz
D_{MAX}	Maximum duty cycle				100%		
D_{MIN}	Minimum duty cycle			0%			
V_{TRIKL}	Trickle charge threshold voltage (4.2V） (3.6V)	RS=1Ω, V_{BAT} Rise		2.7 2.4	2.9 2.5	3.0 2.6	V V
V_{TRHYS}	Trickle charging hysteresis voltage	RS=1Ω		60	80	100	mV
V_{UV}	VIN Undervoltage Lockout threshold	VIN From low to high	●	3.5	3.7	3.9	V
V_{UVHYS}	VIN Undervoltage Lockout hysteresis		●	150	200	300	mV
VADPT		VIN From high to low		4.1	4.3	4.5	
V_{ASD}	VIN-VBAT Lockout threshold voltage	VIN From low to high VIN From high to low		60 5	100 30	140 50	mV mV
$V_{\overline{CHRG}}$	$\overline{CHRG}$ Pin output low voltage	$I_{\overline{CHRG}}$ =5mA			0.3	0.6	V
$V_{\overline{STDBY}}$	$\overline{STDBY}$ Pin output low voltage	$I_{\overline{STDBY}}$ =5mA			0.3	0.6	V
V_{TEMP-H}	TEMP Pin high-end shutdown voltage				>80	82	%*VIN

V_{TEMP-L}	TEMP Pin low-end shutdown voltage			43	<45		%*VIN
ΔV_{RECHRG}	Rechargeable battery threshold voltage	V_{FLOAT}-V_{RECHRG}		100	150	200	mV
T_{LIM}	Chip protection temperature				145		℃
R_{ON}	Power FET on-resistance				260		mΩ
t_{ss}	Soft-start time	IBAT=0 to I_{BAT}=0.1V/Rs			20		uS
$t_{RECHARGE}$	Recharge Comparator Filter Time	VBAT High to Low		0.8	1.8	4	mS
t_{TERM}	Termination Comparator Filter Time	IBAT Below C/10		0.8	1.8	4	mS

Typical performance indicators (CS set to 4.2V lithium battery charging mode)

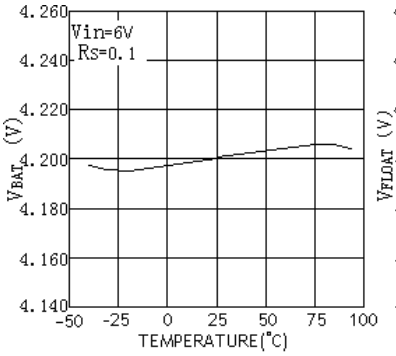


Figure 4

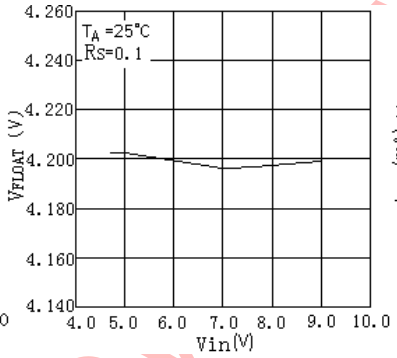


Figure 5

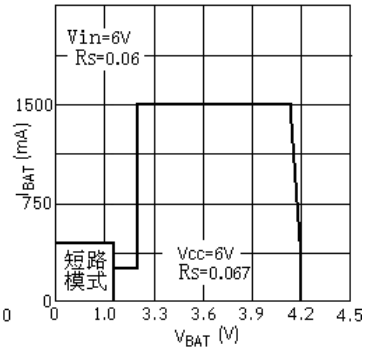


Figure 6

Figure 4: Cut-off voltage and ambient temperature relationship

Figure 5: The date of the relationship between battery voltage and supply voltage

Figure 6: Charging current and battery voltage relationship

Pin Function

VIN (Pin1, 2, 16): the positive input terminal of the input voltage. The voltage on this pin for internal circuit power supply, and the VIN changes in the range of 4.5V to 9V and a 10μF tantalum capacitor bypass. When the VIN and VBAT differential pressure is lower than 30mv, TP5000 enter shutdown mode, the dropped 4μA so IBAT.

LX (Pin3,4,5): built-in the PMOSFET power pipe drain connection. LX is TP5000 the current output terminal and is connected to the external inductor as the input terminal of the battery charging current.

GND (Pin6,7): Power Ground.

VS (Pin8): Output current sense positive input terminal.

BAT (Pin9): battery voltage detection terminal. To the positive terminal of the battery is connected to this pin.

VREG (pin10): internal power supply. The VREG is an internal power supply, external 0.1uF bypass capacitor to ground.

TS (Pin11): The battery temperature detection input. TS pin to the NTC (negative temperature coefficient thermistor) sensor output terminal of the battery. If the TS pin voltage is less than 45% of the input voltage or greater than 80% of the input voltage, which means that the battery temperature is too low or too high, the charging is suspended. If TS is directly tied to GND, battery temperature detection function is canceled, the other charging function properly.

RTRICK (Pin12): Trickle pre-charge current setting end. Pre the RTRICK pin to ground charging current set at 10% constant current, pre-charging current can be set by an external resistor. If RTRICK vacant then the pre-charge current is equal to the constant current.

CS (Pin13): lithium-ion or LiFePO4 status chip select input. CS pin high input level will TP5000 is the lithium-ion battery charging a 4.2V voltage shutdown state. The CS left side in the TP5000 iron phosphate lithium-off voltage 3.6V. Low input level TP5000 is shutdown. CS client can be TTL or CMOS level driver.

$\overline{\text{STDBY}}$ (Pin14): Battery Charge complete indication end. When the battery is fully charged, the internal switch is pulled low, the charging is completed. In addition, the pin will be in a high impedance state.

$\overline{\text{CHRG}}$ (Pin15)： Charge indicator status. Charger to charge the battery, pin internal switch pulled low, indicating that charging is in progress; otherwise the pin is in a high impedance state.

Operational principle

TP5000 is designed specifically for single 4.2V lithium-ion/3.6V LiFePO4 battery switching current charger chip, the use of the power transistors of the chip's internal battery trickle, constant current and constant voltage charging. The charging current can be set with an external resistor programming, maximum continuous charge current up to 2A, and does not require additional anti-intrusion diode.TP5000 consists of two open-drain output status outputs, charge status output $\overline{\text{CHRG}}$ and the battery is fully charged status

outputs $\overline{STDBY}$.

Chip power management circuitry automatically reduces the charge current when the chip junction temperature exceeds 145 ° C, this feature allows users to maximize the use of the power handling capability of the chip, and do not have to worry about the chip overheating and damage to the chip or the external components.

When the input voltage is greater than the chip start-up threshold voltage and chip enable input the high termination or floating, TP5000 start charging the battery, $\overline{CHRG}$ pin output low, which means that charging is in progress. If the lithium-ion battery voltage is below 2.9V (lithium iron phosphate battery voltage is lower than 2.5V) battery trickle charger with a small current pre-charge (pre-charge current adjustable via an external resistor). Constant charge current is determined by the resistance between the VS pin and VBAT pin. When the lithium-ion battery voltage is close to 4.2V (lithium iron phosphate close to 3.6V), from the charge cut-off voltage of about 50mV (depending on the circuit connection resistance and the internal resistance of the battery voltage), the charging current decreases, TP5000 enters the constant charge mode. The end of the charge cycle when the charge current is reduced to the cut-off current, $\overline{CHRG}$ Pin output high-impedance state, $\overline{STDBY}$ Pin output low.

When the battery voltage falls below the recharge threshold (LiFePO4 battery 4.1V, lithium iron phosphate battery 3.5V), automatically starts a new charge cycle. Chip precision internal voltage reference, error amplifier and the resistor divider network to ensure the accuracy of the cut-off voltage of the battery terminal within + -1%, to meet the charging requirements of the lithium-ion battery and lithium iron phosphate. Power-down when the input voltage or the input voltage is lower than the battery voltage, the charger enters a low power shutdown mode, no external anti-intrusion diode, battery leakage from the chip close to 4uA.

Charging cut-off voltage selector

The TP5000 has two charging cut-off voltage of the single-cell lithium ion / LiFePO4 choice. When the CS terminal is connected to the high potential VIN, 4.2V lithium-ion battery charging standard cut-off voltage 4.2V. When CS-side vacant, LiFePO4 charging standard cut-off voltage of 3.6V. When CS low termination GND, the charger stops charging.

The TP5000 CS side composite design, can be determined by the external control TP5000 is in charge mode and stop mode switch.

4.2V lithium-ion battery state of charge and shutdown mode switching. As shown in Figure 7, an open-drain output ports and CS terminal connected， the NMOS gate input low, N1 deadline CS high termination charge cut-off voltage to 4.2V lithium TP5000 ion batteries. Gate input high when the NMOS transistor N1 is turned on, the CS pin is pulled down to GND TP5000 shutdown mode.

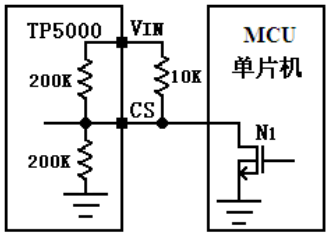


Figure 7 switch controlled by external 4.2V lithium-ion battery state of charge and stop state

3.6V LiFePO4 state of charge and the stopped state switching. As shown in Figure 8, the NMOS transistor gate input low, N1 deadline, the CS side vacant, the charge cut-off voltage

for 3.6V the TP5000 LiFePO4 charging. When the NMOS gate input high, N1 conduction, CS end is pulled down to GND TP5000 shutdown mode.

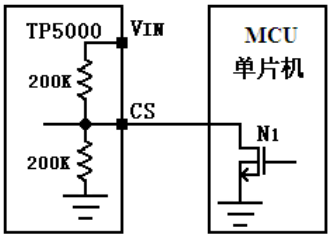


Figure 8 switch controlled by external LiFePO4 state of charge and stop state

Charge current setting

Battery charging current IBAT R is determined by the external current sense resistor Rs. Across this resistor (Rs) to adjust the threshold voltage and constant current to determine the ratio of the charging current, the voltage across the resistor (Rs) under a constant current state as 100mV.

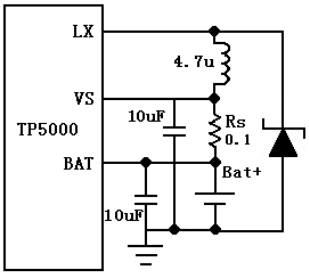


Figure 9 Battery charging current is set to

Setting resistor and the charge current using the following formula to calculate the:

$$R_S = \frac{0.1V}{I_{BAT}} \quad (I \leqslant 500mA)$$

$$R_S = \frac{0.095V}{I_{BAT}} \quad (I > 500mA)$$

(Current units A, resistance units Ω).

Examples: Need to set the charging current is 1A, into the formula Rs=0.1Ω

Table 2 shows some of the settings corresponding to the type of current resistor Rs, fast and easy to design the circuit.

Table 2: RS and its corresponding constant current charge current

RS (Ω)	I_{RBAT} R(mA)
1	100
0.2	500
0.1	950
0.062	1530
0.05	1900
0.047	2000

Trickle pre-charge current is set

If the battery voltage is lower than the pre-charge threshold voltage, the TP5000 will start a pre-charging process to charge the battery, the TP5000 pre charge current by TRICK port settings. The pre-charge current is set by a resistor connected between the in TRICK pin ground.

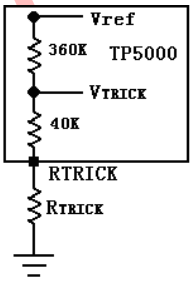


Figure 10 The TRICK end internal circuit diagram

As can be seen from the figure 10, If RTRICK port directly grounded resistor stars pressure to get the voltage ratio is a precharge trickle flow and constant current charging current ratio. Then pre-charge current is 1/10 of the charging current of the constant current. This pin change only a trickle, not affected by this shutdown current, remained at 10% constant current.

Setting resistor and pre-charge current is calculated using the following formula:

$$R_{TRICK} = \frac{400kI_{TRICK} - 40kI_{BAT}}{I_{BAT} - I_{TRICK}}$$

In order to facilitate the customers to design, table 3 shows the relationship RTRICK set

precharge the trickle current with constant current IBAT.

Table 3: RTRICK their settings trickle current and constant current IBAT relationship:

RTRICK (K)	ITRICK (mA)
0	10% IBAT
50k	20% IBAT
114k	30% IBAT
320k	50% IBAT
NC	100% IBAT

Charge termination

Constant voltage phase, when the charge current drops to 1/10 of the maximum constant value, the charge cycle is terminated. This condition is detected by using an internal comparator filter to monitor the pressure drop Rs. When the voltage across Rs Poor to time exceeds 10mV or less (typically 1.8ms), charging is terminated. The charging current is off, TP5000 enters standby mode, the input supply current drops to 170μA, Battery drain current outflow about 4uA.

In standby mode, the TP5000 continuous monitoring of the BAT pin voltage. If the lithium-ion battery to this voltage drops below 4.1V rechargeable (LiFePO4 voltage drops to 3.5V) switches below the limit, the new charge cycle begins and again supply current to the battery.

Charging status indicator

TP5000 has two open-drain status output terminal, $\overline{CHRG}$ and $\overline{STDBY}$. When the charger is charging, $\overline{CHRG}$ is pulled low, in other states, $\overline{CHRG}$ in a high-impedance state. When the battery temperature is outside the normal temperature range, $\overline{CHRG}$ and $\overline{STDBY}$ the pins are high impedance. When the status indicator is not used, the unused pin is connected to the ground.

Table 4: charging indicator status

Green $\overline{STDBY}$	Red $\overline{CHRG}$	State of charge
OFF	ON	Is charging state
ON	OFF	The battery is fully state
OFF	OFF	Under-voltage, battery temperature is too high, too low fault condition or without battery access. (TS used)
Green light, red light flashes T=0.5-2S		BAT Connect the 10u capacitors, battery standby state (TS connected to ground)

Battery over-temperature protection

In order to prevent the temperature is too high or too low the damage caused by the battery, TP5000 integrated battery temperature detection circuit. The battery temperature detection is achieved by measuring TS pin voltage, the voltage of the TS pin is realized by the NTC thermistor inside the battery, and a resistor divider network, as shown in Figure 11. TP5000 two threshold TS pin voltage with the chip and compared to confirm that the battery temperature is outside the normal range. Within TP5000 is fixed to be fixed in. If the TS pin voltage, it means that the battery temperature is too high or too low, the charging process will be suspended; TS pin voltage between and the charge cycle resumes. If the TS pin to ground, the battery temperature detection function will be disabled.

Example: room temperature 25 ℃ under RNTC = 10k, the set protection temperature 60℃, 60℃ under RNTC = 3k, then the calculation was RNTC= 3.6K, the NTC resistor divider ratio of 45% of the supply voltage, is 60 ℃ TP5000 stop charge.

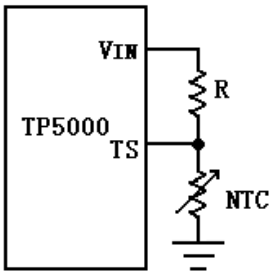
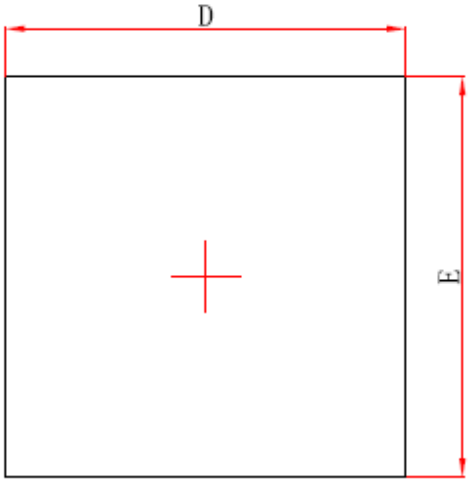


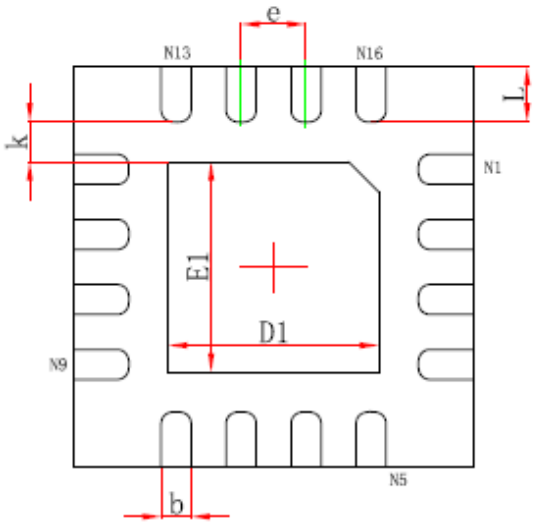
Figure 11 NTC connection diagram

Package Description

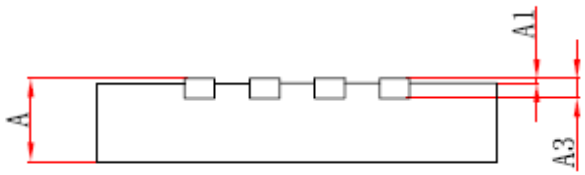
4mm * 4mm 16-pin QFN package



Top View



Bottom View



Side View

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.700/0.800	0.800/0.900	0.028/0.031	0.031/0.035
A1	0.000	0.050	0.000	0.002
A3	0.203REF.		0.008REF.	
D	3.900	4.100	0.154	0.161
E	3.900	4.100	0.154	0.161
D1	2.000	2.200	0.079	0.087
E1	2.000	2.200	0.079	0.087
k	0.200MIN.		0.008MIN.	
b	0.250	0.350	0.010	0.014
e	0.650TYP.		0.026TYP.	
L	0.450	0.650	0.018	0.026

Package	Reel	Pcs/ disc	Tray / box	Boxes / carton	Pcs / box
QFN4*4	13Inch	5000	1	8	40000

The TP5000 other application circuit

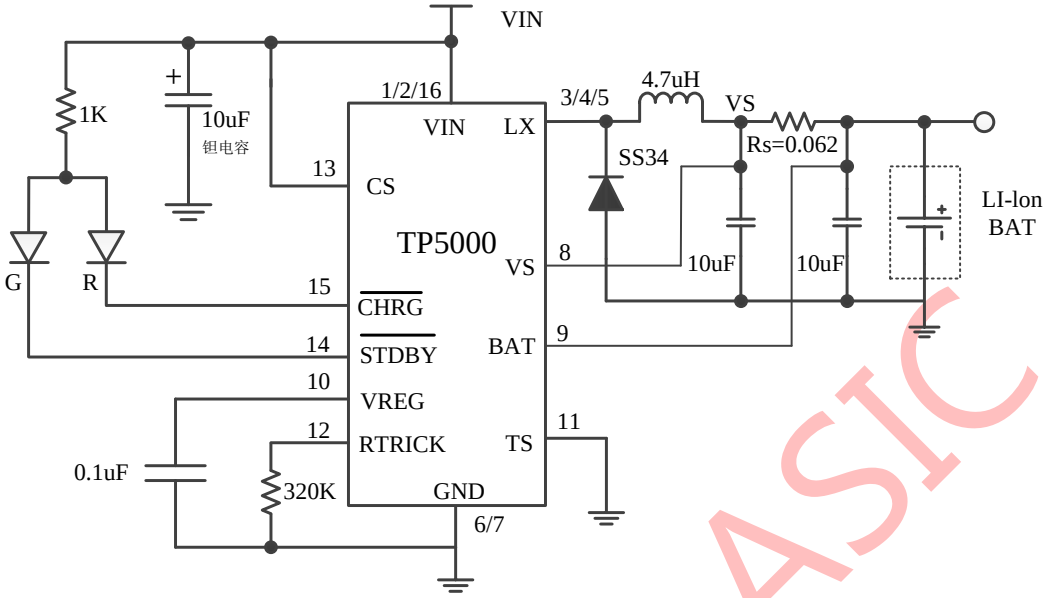


Figure 12 TP5000 4.2V lithium-ion battery battery temperature protection trickle 0.75A constant current 1.5A charging Application Diagram (CS pin high)

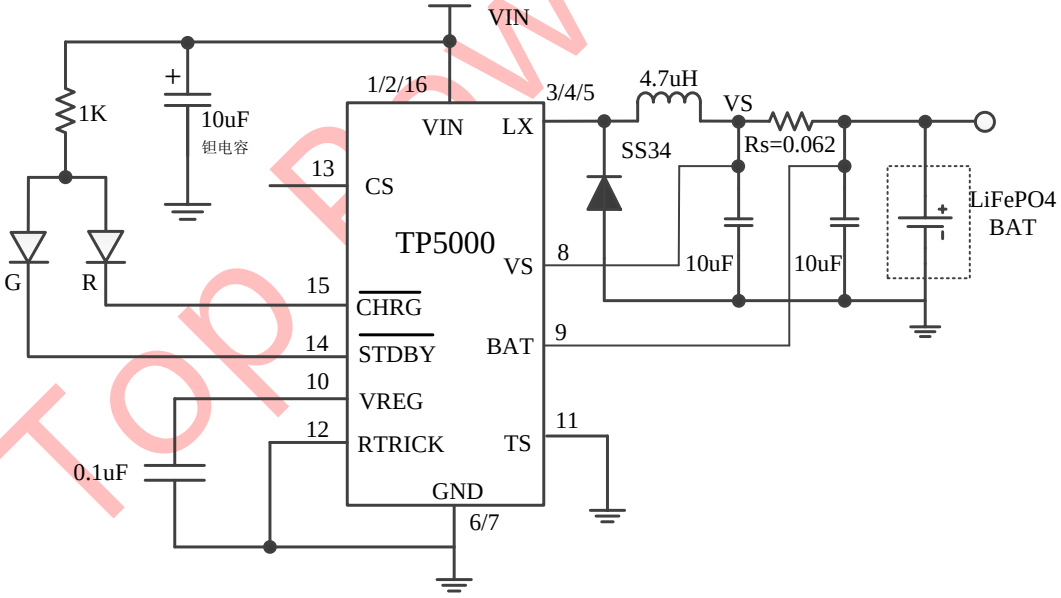


Figure 13 TP5000 LiFePO4 battery temperature protection the 1.5A charge Application Diagram (CS pin floating)

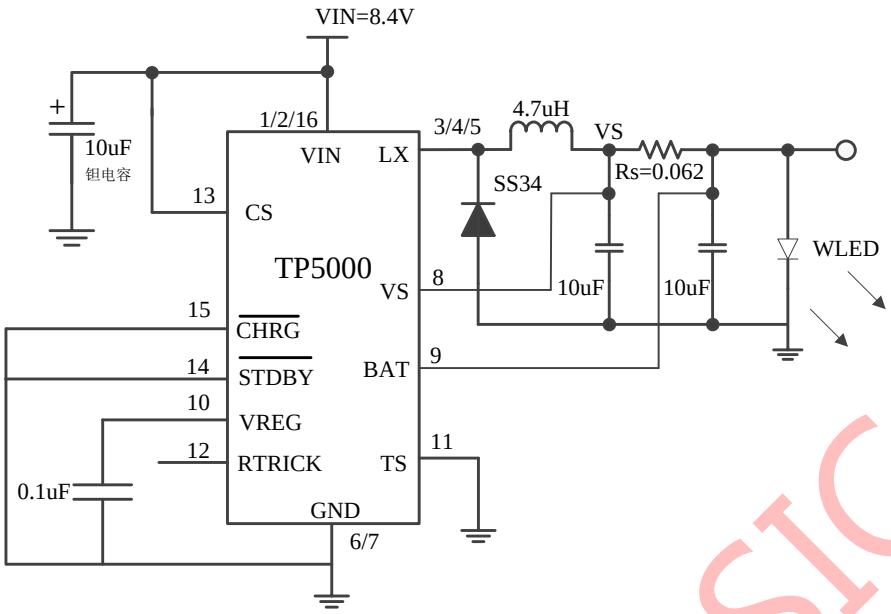


Figure 14 TP5000 The two connected lithium battery drive 5W LED Application Diagram (The RTRICK pin unconnected)

TP5000 Note

1、The circuit capacitance should be as close as possible to the chip.

2、The VS end of the VIN end and BAT end use of tantalum capacitors, X5R or X7R level ceramic capacitors or electrolytic capacitors plus 0.1uF ceramic capacitor.

3、The inductor selection of the current capacity is sufficient power inductor.

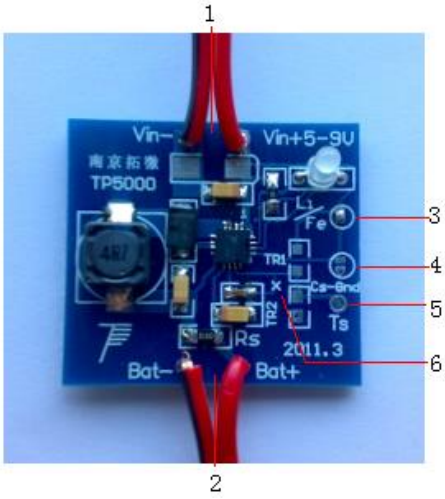
4、The Schottky diode choose conduction voltage drop current capability greater than or equal to 2A Schottky diode.

5、For VIN and LX should be wider than the ordinary signal lines through the traces of the current loop.

6、Pay attention to the capacitive grounding line node location, and should try to make the ground point focused, well-grounded.

7、Use the chip in the high-current work, should be considered a good connection of the chips at the bottom of the heat sink and the PCB to ensure good heat dissipation.

TP5000 Demo board circuit and instructions



Components	Type	Package	Quantity
Chip	TP5000	QFN16	1
Inductance	4.7uH		1
Tantalum capacitors	10uF	1206	3
Ceramic capacitors	0.1uF	0603	1
Schottky diode	S495		1
RS Resistance	0.062 Ω or (0.1Ωparallel 0.2Ω)	1206	1
LED Limiting resistor	1kΩ	0805	1
Red and green common anode LED		3mm	1

TP5000 Pin and port of the demo version:

Input: Vin + Vin-(No. 1)

Output: Bat + Bat-(No. 2)

CS：Default 4.2V lithium manganese charging mode, CS connect Vin. The solder adhesion of use (No. 3);

For the 3.6V LiFePO4 charge mode, CS vacant, no adhesion need to change (No. 3);

CS = GND shutdown mode, need (No. 3) prohibits adhesions, (No. 4) pad adhesion can be.

(No. 3) (No. 4) non-adhesion at the same time.

TS： Default does not use the temperature sensor TS = GND, if the cross-wire (No. 6) cut customers can resistance RNTC size divider resistors to set aside TR1, TR2 two 0805 pad design. TR1 to TS the Vin resistance TR2 TS to GND resistors for.

RS: Charging current default 1.5A, Figure RS resistor 1206 resistor. Customers according to their needs and design changes.

RTRICK：Ground, the default pre-charge current of 10% constant current.

Test Description:

Properly connected power supply and battery, you can charge, charging the red light, charging the

end of the green light.

Constant current charging the battery positive terminal series ammeter, detect the charging current, ammeter use a large number of process file. Taking into account the internal resistance of the ammeter is not recommended in the final test series ammeter fully charged battery voltage mode. The internal resistance of the battery will cause the shut off the actual voltage turn-off voltage is lower than the chip itself.

For driving white LEDs, simply adjust the suitable current output (No. 2)

Bat + Bat-connected white LED cathode and anode.

Attention to the selection of the Schottky diode reverse leakage current is less than 1uA. Ammeter in series is not recommended in the test eventually fully charged battery voltage mode, The internal resistance of the battery will cause the shut off the actual voltage turn-off voltage is lower than the chip itself.

The battery reversed the chip will not be damaged, but the battery through the Schottky diode, inductor, RS circuit short-circuited itself.

To replace the chip, it is recommended to use a hot air gun welding equipment.