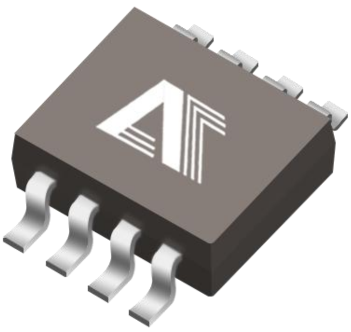
AOTE
SEMICONDUCTOR



Lithium electronic battery charger

TP4056H

Product Data Sheet

AOTE DCC
RELEASE

◆ Summary ：

The TP4056H series is a linear lithium battery charging chip with an input maximum withstand voltage of 33V and a maximum charging current of 1.2A. It adopts trickle/constant current/constant voltage charging methods. The charging voltage is set to 4.2V or 4.35V, and the charging current can be set through an external resistor.

When the battery voltage reaches 4.2V or 4.35V and the charging current drops to C/5 or C/10 of the set value, TP4056H stops charging and the chip enters standby mode. When the power is removed, TP4056H automatically enters low-power standby mode. TP4056H is suitable for working with USB power supplies and adapter power supplies. Due to the use of internal PMOSFET architecture and anti reverse charging circuit, there is no need for external detection resistors and isolation diodes.

◆ Product features

- Suggested working voltage: 4.5V~5.5V
- Maximum input maximum withstand voltage: 33V
- Supports hot swappable 28V (input end connected to RC absorption)
- Overvoltage protection voltage: 6.8V (typical value)
- programmable charging current up to 1.2A
- 4.20V or 4.35V preset charging voltage with an accuracy of up to 1%
- No need for external MOSFET, detection resistor and isolation diode
- Constant current/constant voltage operation
- Charging status, charging termination, no battery, and fault status display
- The static current in standby mode is 1.0 μ A (typical value)
- can activate 0V battery charging
- BAT terminal battery positive and negative pole anti reverse protection
- 2.9V trickle charging threshold; C/5 or C/10 charging termination
- Automatic Recharge (Recharge)
- Soft start limits surge current
- Adjust the charging current after the junction temperature reaches 130 ℃, and turn off charging at 155 ℃
- Working temperature range: -40 ℃ to 105 ℃
- Packaging form: ESOP8

◆ Applications

- Neck mask gun, electronic cigarette
- Bluetooth earphones GPS、 wearable devices
- Portable devices such as digital cameras, Mini speakers, electronic toys, etc
- Hair clippers, razors, and various chargers

◆ Selection Table

<table>
<tr><th>Model</th><th>Float voltage</th><th>Charging cut-off current/trickle charging current</th><th>CE effective level</th><th>Encapsulation</th><th>Remark</th></tr>
<tr><td rowspan="4">TP4056H</td><td rowspan="4">4.20V</td><td>C/5</td><td rowspan="2">highly effective</td><td rowspan="4">ESOP8</td><td></td></tr>
<tr><td rowspan="2">C/10</td><td></td></tr>
<tr><td rowspan="2">active-low</td><td></td></tr>
<tr><td>C/5</td><td></td></tr>
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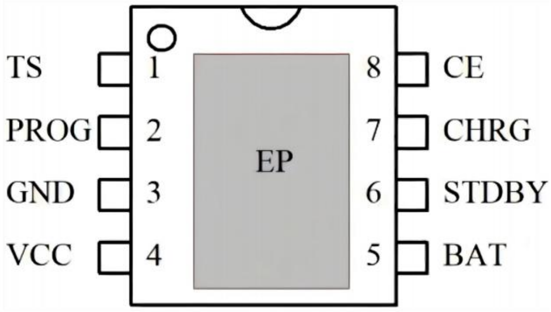
Note: Float charging voltage is optional (4.05V/4.20V/4.35V/4.4V), default 4.20V

Pin arrangement diagram and pin description

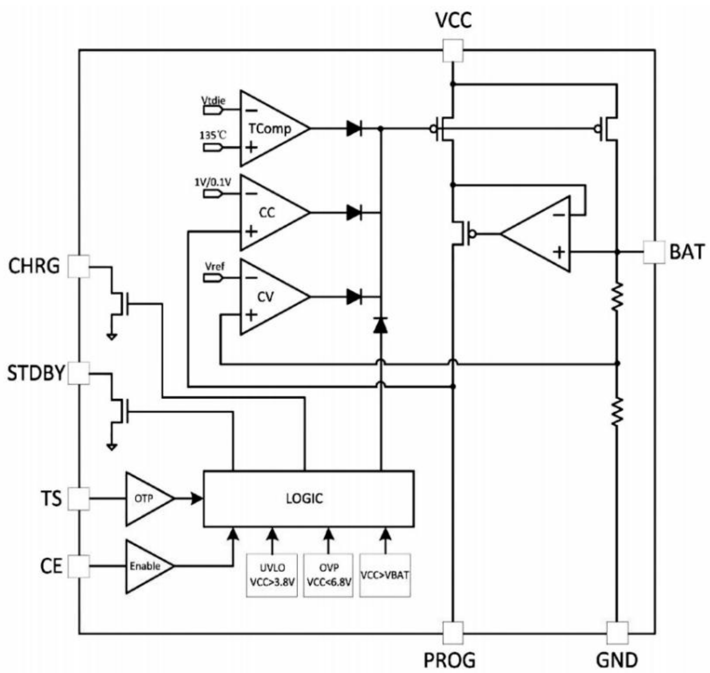
Pin diagram



Pin Description

Serial Number ESOP8	Name	Functional Description
1	TS	Battery NTC temperature detection input terminal, grounded to TS when not in use
2	PROG	Programmable charging current setting terminal
3	GND	GnD
4	VCC	Power pin
5	BAT	Connect the positive pole of the battery
6	STDBY	Battery charging completion indicator terminal
7	CHRG	Battery charging status indicator terminal
8	CE	Chip enabled pins, highly effective

Functional Block Diagram



  Release Date :April 7, 2026 www.aotesemi.com 版本：B1

◆ Parameter characteristics

(Limit parameter)

Project	Symbol	Scope	Unit
V_{IN} 、CE input voltage	V_{IN}、V_{CE}	-0.3~33	V
BAT terminal voltage	V_{BAT}	-0.3~12	
PROGterminal voltage	V_{PROG}	-0.3~10	
CHRG、STDBY、TSterminal voltage、STATE	V_{CHRG}、V_{STDBR}、V_{TS}	-0.3~33	
BAT Pin max current	I_{BAT}	1500	mA
PROG Pin max current	I_{PROG}	1.2	
Power dissipation PD@T_A=+25℃	P_D (ESOP8)	650	mW
Storage temperature range	T_{STG}	-65~+150	℃
Maximum working junction temperature	$T_{J(MAX)}$	155	
Encapsulation thermal resistance	$\theta_{JA(ESOP8)}$	200	℃/W
Pin soldering temperature(Soldering,10sec)	T_{LEAD}	260	℃
ESD static electricity(Human Body Mode)	V_{DD} To GND≥5K		V

Note: Exceeding the limit parameter values may damage the components and cannot guarantee that the equipment will operate outside of its working conditions

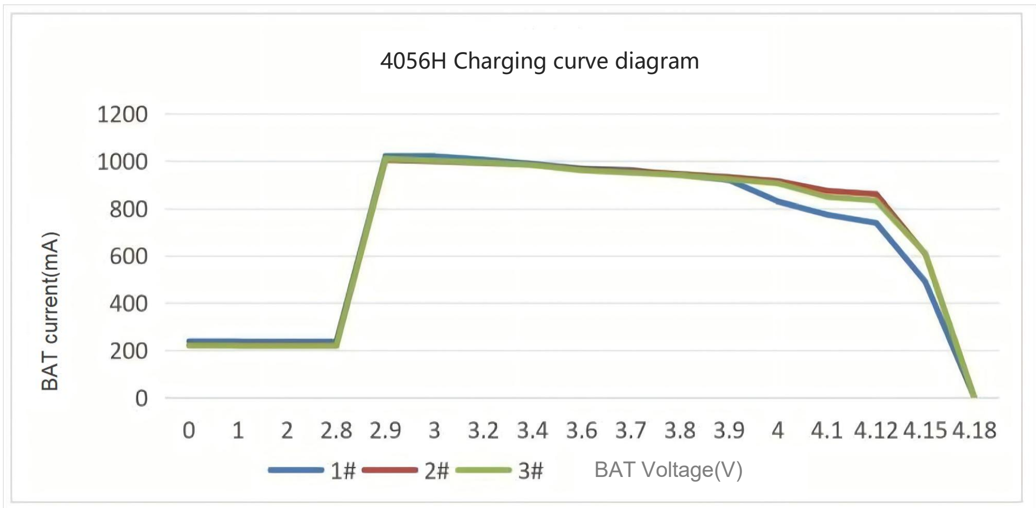
◆ Electrical Characteristics

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input power supply voltage	V_{IN}		4.5	5.0	5.5	V
Input overvoltage lockout threshold voltage	V_{OVLO}		6.6	6.8	7.0	
Input overvoltage lock threshold hysteresis	$V_{OVLO-HYS}$			500		mV
Input power supply current	I_{CC}	Charging mode(P_{PROG}=2K)		200	350	uA
		Standby mode (charging terminated)		100	150	
		Shutdown mode(P_{PROG} Not Connected) V_{CC}<V_{BAT},or V_{CC}<V_{VLO}		55	100	
Stable output (float charging) voltage	V_{FLOAT}	0℃≤T_A ≤85℃, I_{BAT}=40mAV	4.158	4.20	4.242	V
			4.306	4.35	4.393	
BAT charging current	I_{BAT}	constant current mode, P_{PROG}=1K	950	1000	1050	uA
		standby mode，V_{BAT}-4.20V		1.0		
		Shutdown mode，(P_{PROG} Not Connected)		1.0		
		sleep mode，V_{CC}=0V		0.1		
trickle charge current	I_{TRIKL}	V_{BAT}<V_{TRIKL},P_{PROG}=1K,C/5	160	200	240	mA
		V_{BAT}<V_{TRIKL},P_{PROG}=1K,C/10	80	100	120	
Trickle charging threshold voltage	V_{TRHYS}	P_{PROG}=1K,V_{BAT} rise	2.8	2.9	3.0	V
Trickle charging hysteresis voltage	V_{UVHYS}	P_{PROG}=1K,V_{BAT} fall	40	80	120	mV
VCC Undervoltage protection threshold voltage	V_{OVLO}	V_{CC} From low to high	3.6	3.8	4.0	V
VCC Undervoltage lockout hysteresis voltage	V_{UVHYS}	V_{CC} fall	150	200	250	mV
Manually turn off the threshold voltage	V_{MSD}	V_{PROG} rise	0.9	1.0	1.1	V
		V_{PROG} fall	0.9	1.0	1.1	
VCC-VBAT Locking voltage	V_{ASD}	V_{CC} rise	50	100	150	mV
		V_{CC} fall	35	50	75	
Termination current threshold	I_{TERM}	P_{PROG}=1K,C/5	160	200	240	mA
		P_{PROG}=1K,C/10	80	100	120	
PROG Pin voltage	V_{PROG}	constant current mode,P_{PROG}=1K	0.9	1.0	1.1	V
CHRG End output low level	V_{CHRG}	I_{CHRG}=5mA		0.35	0.5	
STDBY End output low level	V_{STDBY}	I_{STDBY}=5mA		0.35	0.5	
Rechargeable battery threshold voltage	V_{RECHG}	I_{FLOAT}-V_{RECHG}	100	150	200	
Recharging delay time	V_{RECHG}	V_{BAT} From high to low		1.2		ms
CE Enable threshold voltage	V_{CEH}	CE From low to high		1.2		V
CE Turn off threshold voltage	V_{CEL}	CE From high to low		0.8		
TS High end flip voltage of the foot	V_{TS_H}	TS pick up NTC resistance		80		%VCC
TS Low end flipping voltage of the foot	V_{TS_L}	TS pick up NTC resistance		45		
Charging termination delay time	t_{TERM}	I_{BAT} 降至I_{CHRG}/10 以下		1.6		ms
PROG Pull up current at the end	I_{PROG}			2.0		uA
power FET Conduction resistance	R_{ON}			500		mΩ
Soft start time	t_{SS}	I_{BAT}=0~I_{BAT}=1000/P_{PROG}		450		us
Junction temperature in limited temperature mode	T_{LIM}			155		℃

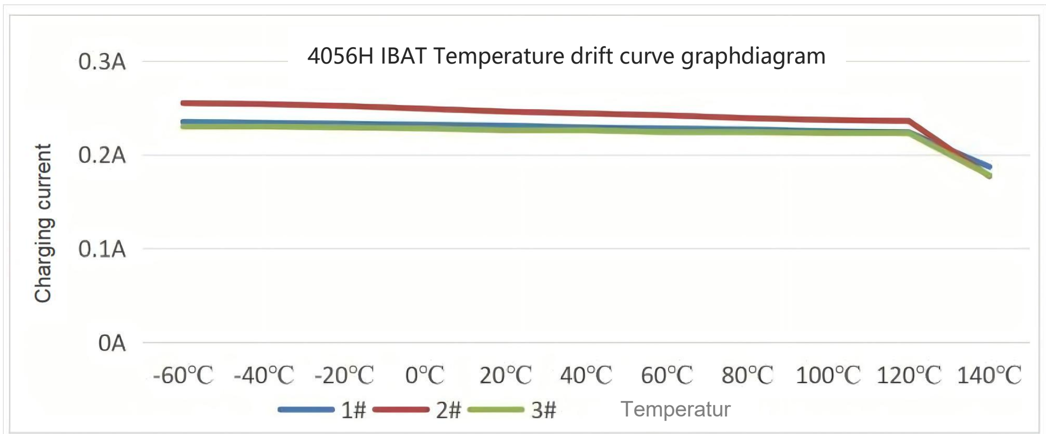
Note: Some parameters may have slight differences due to different batches

◆ Temperature drift curve

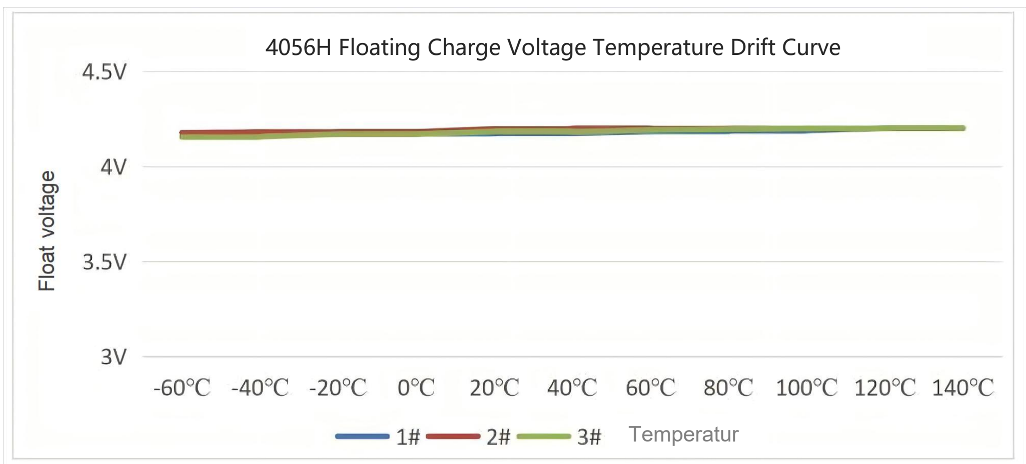
Charging curve(V_{IN}=5V,P_{ROG}=1K)



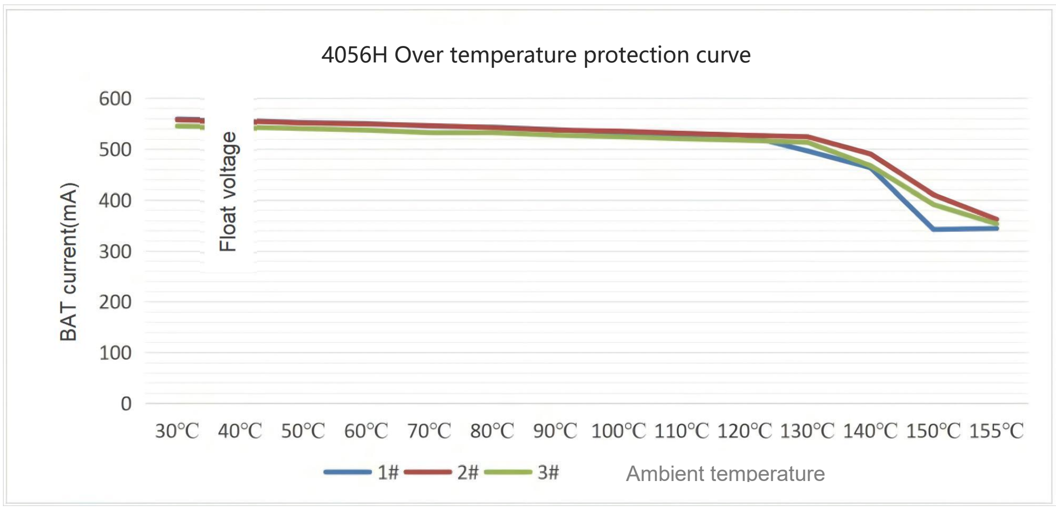
Charging temperature drift curve(V_{IN}=5V,P_{ROG}=5.1K)



Floating voltage temperature drift curve(V_{IN}=5V,P_{ROG}=5.1K)



Over temperature protection point (V_{IN}=5V,P_{ROG}=2K)



◆ Working principle

TP4056H is a linear charging circuit for single lithium-ion or lithium polymer batteries, which uses the power MOSFET inside the chip to charge the battery at constant current/constant voltage. The charging current can be programmed by an external resistor, and the maximum charging current can reach 1200mA.

TP4056H has two open drain output status indicator output terminals, a charging status indicator terminal CHRG and a battery charging completion indicator output terminal STDBY. The power transistor circuit inside the chip automatically reduces the charging current when the junction temperature of the chip exceeds 130℃. This function allows users to maximize the use of the chip for charging. When the temperature reaches 155℃, the charging will be turned off without worrying about the chip overheating and damaging the chip or external components.

TP4056H has input power overvoltage protection function, ensuring that the chip is not damaged in complex input environments.

Normal charging

When the voltage of the VCC pin rises above the UVLO threshold level and a set resistor with an accuracy of 1% is connected between the PROG pin and ground, a charging cycle begins. If the BAT pin level is below the trickle charging threshold voltage of 2.9V, the charger enters trickle charging mode, in which TP4056H provides a set charging current of approximately C/5 or C/10 to raise the current voltage to a safe level. When the BAT pin voltage rises above the trickle charging threshold voltage, the charger enters constant current mode and provides a constant charging current to the battery. When the BAT pin voltage reaches the final float voltage of 4.2V, TP4056H enters constant voltage mode and the charging current begins to decrease. When the charging current drops to C/5 or C/10 of the set value, the charging cycle ends.

Charging current setting

The charging current is set using a resistor connected between the ROG pin and ground. The charging current is 1000 times the output current of the ROG pin. The resistor and charging current are calculated using the following formula:

$$P_{PROG} = \frac{1000}{I_{CHRG}} \text{ 或者 } I_{CHRG} = \frac{1000}{P_{PROG}}$$

The charging current output from the BAT pin can be determined at any time by monitoring the voltage of the PROG pin, and the formula is as follows:

$$I_{BAT} = \frac{V_{PROG}}{P_{PROG}} * 1000$$

In applications where the charging current is set to be greater than 1A, the heat generated by the chip is relatively high, and temperature protection will reduce the charging current. The testing current in different environments may not be completely consistent with the theoretical value calculated by the formula. In the customer application, the appropriate size of Pmoc can be selected according to the needs, and the recommendation table can be selected:

PPROG(KΩ)	ICHRG(mA)
0.82	1200
0.91	1100
1	1000
1.1	900
1.2	800
2	500
5.1	200
10	100
20	50
33	30

Charging terminated

When the charging current drops to C/5 or C/10 of the set value after reaching the final float voltage, the charging cycle is terminated. This condition is detected by monitoring the ROG terminal using an internal filtering comparator. When the voltage at the ROG terminal drops below 200mV (C/5) or 100mV (C/10), charging is terminated and TP4056H enters standby mode. At this time, the input power supply current drops to about 100uA.

Charging status indication

TP4056H has two open drain state indicating output terminals, CHRG and STDBY. When the charger is in a charging state, CHRG is pulled to a low level, and in other states, CHRG is in a high impedance state. When the battery is not connected to the charger, CHRG outputs a pulse signal indicating that the battery is not installed. When the external capacitor connected to the battery terminal is 1uF, the CHRG flashing period is about 0.1-0.8 seconds. When the external capacitor connected to the BAT pin of the battery terminal is 10uF, the CHRG flashing period is about 1-2 seconds. When the status indicator function is not in use, connect the output terminal of the unused status indicator to ground. The following is the complete status of the indicator light:

Charging status	CHRG lamp	STDBY lamp
Charging status in progress	bright	extinguish
Battery fully charged state	extinguish	bright
Input undervoltage, overvoltage, battery reverse connection	extinguish	extinguish
BAT terminal connected to 10uF capacitor, no battery	Twinkle 1-2S	bright

Heat restriction

If the chip temperature rises above 130 ℃, an internal thermal feedback loop will reduce the set charging current, and if it exceeds 155 ℃, the output will be directly turned off. This function can prevent TP4056H from overheating and allow users to increase the upper limit of the given circuit board's power processing capability while reducing the risk of damaging TP4056H.

Undervoltage lockout

An undervoltage lockout circuit inside TP4056H 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 jumps, the charger will not exit the shutdown mode until VCC rises to 100mV higher than the battery voltage.

Automatic cycle charging

After the battery voltage reaches the float charging voltage and the charging cycle is terminated, TP4056H immediately monitors the BAT terminal voltage. When the BAT terminal voltage is below 4.05V (floating charge 4.20V) or around 4.20V (floating charge 4.35V), the charging cycle starts again. Ensure that the battery is maintained in a state close to full charge, while eliminating the need for periodic charging cycles to start.

Battery reverse connection protection

TP4056H has a built-in lithium battery reverse connection protection function. When the lithium battery is reverse connected to the BAT pin of the chip, the chip will shut down and display a fault status. At this time, the leakage current of the reverse connected lithium battery is about 0.1mA. Connect the reversed battery correctly, and the chip will automatically start a charging cycle. After the reverse connection of the chip, if the battery is removed, the charging indicator light will not immediately light up normally due to the negative capacitance potential of the BAT pin on the chip output terminal. Only by correctly connecting the battery can the charging be automatically activated. Alternatively, wait for the negative potential of the BAT terminal capacitor to emit light. If the BAT terminal potential is greater than OV, the chip will display a normal no battery indicator light status.

Charging current soft start

TP4056H includes a soft start circuit to minimize inrush current at the beginning of the charging cycle. When a charging cycle is initiated, the charging current will rise from 0 to full scale value in approximately 450us. During the startup process, this can minimize the transient current load on the power supply to the greatest extent possible.

Input power voltage protection (OVP)

TP4056H has the function of inputting power supply voltage OVP. When the VCC input voltage reaches 6.8V, the chip OVP protection is activated, and the chip stops charging the battery; When the power supply voltage drops to 6.2V, the chip enters the working state again.

Battery temperature monitoring

In order to prevent damage to the battery caused by high or low temperatures, TP4056H integrates a battery temperature monitoring circuit internally. Battery temperature monitoring is achieved by measuring the voltage of the TS pin, which is realized by the NTC thermistor and a resistor voltage divider network inside the battery. TP4056H compares the voltage of the TS pin with two thresholds VLow and VHIGH inside the chip to confirm whether the temperature of the battery exceeds the normal range. Inside TP4056H, VLOW is fixed at 45% x VCC and VHIGH is fixed at 80% x VCC. If the voltage of the TS pin VTS<VLOW, or VTS>VHIGH, it indicates that the battery temperature is too high or too low, and the charging process will be paused; If the voltage TS at the TS pin is between VLOW and VHIGH, the charging cycle continues.

Determine the values of temperature detection R3 and R4

The values of R3 and R4 should be determined based on the temperature monitoring range of the battery and the resistance value of the thermistor. Here is an example: assuming the set battery temperature range is TL-TH (where TL<TH); The negative temperature coefficient thermistor (NTC) is used in the battery. RTL is its resistance at temperature TL, and RTH is its resistance at temperature TH. Therefore, RTL>RT. At temperature TL, the voltage at the TS terminal is:

$$V_{TS}=\frac{R_4||R_{TH}}{R_3+R_4||R_{TH}}*V_{IN}$$

Then VTS=VHIGH=K2 × VCC, (K2=0.8); VTS=VLOW=K1 × VCC, (K1=0.45) can be solved

$$R_3=\frac{R_{TL}R_{TH}(K_2-K_1)}{(R_{TL}-R_{TH})K_2K_1} \qquad R_4=\frac{R_{TL}R_{TH}(K_2-K_1)}{R_{TL}(K_1-K_2K_1)-R_{TH}(K_2-K_2K_1)}$$

Similarly, if the inside of the battery is a positive temperature coefficient (PTC) thermistor, it can be calculated

$$R_3=\frac{R_{TL}R_{TH}(K_2-K_1)}{(R_{TH}-R_{TL})K_2K_1} \qquad R_4=\frac{R_{TL}R_{TH}(K_2-K_1)}{R_{TH}(K_1-K_2K_1)-R_{TL}(K_2-K_2K_1)}$$

From the above derivation, it can be seen that the temperature range to be set is independent of the power supply voltage VCC and only related to R3, R4, RTH, RTL; Among them, RTH and RTL can be obtained by consulting relevant battery manuals or through experimental testing.

In practical applications, if we only focus on the temperature characteristics of one end, such as overheating protection, then R4 can be omitted and only R3 can be used. Please refer to the application circuit for the positions of R3 and R4.

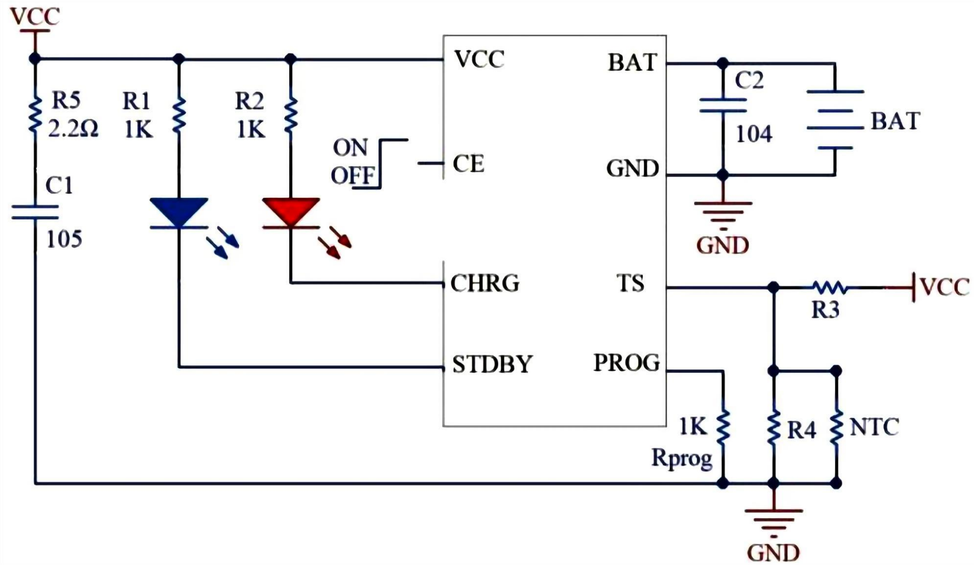
Selection of input and output capacitors and resistors, as well as PCB layout

To ensure reliable use in various situations and prevent chip damage caused by spike and burr voltages, it is recommended to add RC filtering at the input end (please refer to typical application circuits for details). The capacitance values are C1=105 and C2=104. At the same time, the PCB layout requires the capacitor to be as close to the chip pins as possible and not too far away. Suggested resistance value: R1, R2=1K. This resistor cannot be omitted to prevent lamp malfunction.

It is recommended to solder the bottom heat sink (EP) of the chip well to the PCB board during use. The bottom heat dissipation area should have through holes and a large area of copper foil for heat dissipation. Adding sufficient through holes to multi-layer PCBs has a good effect on heat dissipation, but poor heat dissipation may cause a decrease in charging current due to temperature protection. Adding appropriate through holes in the back heat dissipation part also facilitates manual soldering (solder can be poured into the back through holes to reliably solder the heat dissipation surface).

Applied to high current charging (above 1000mA), in order to shorten the charging time, a heat dissipation resistor needs to be added at the VIN end. The resistance range is 0.2~0.4 Ω, and customers can choose the appropriate resistance size according to their usage.

◆ Typical Application Circuit

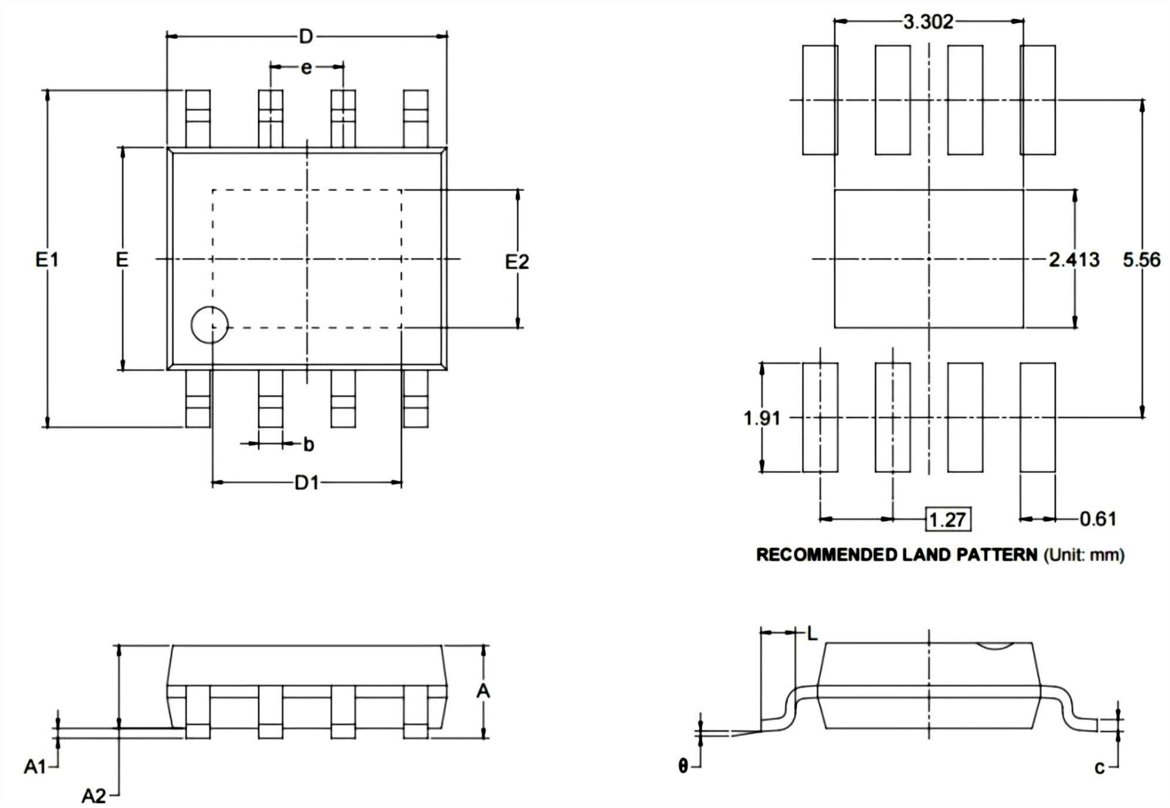


Note:

1. If temperature monitoring is not required, the TS pin must be grounded.
2. If a high-voltage power on environment is required, please refer to the typical application example of RC with 2.2 ohms and luF in series, and optimize the routing layout position.

◆ Encapsulation information

ESOP-8



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	-	1.700	-	0.067
A1	0.000	0.100	0.000	0.004
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
D1	3.202	3.402	0.126	0.133
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	1.27 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

◆ Attention

- AOTE implements dynamic technical updates. Specifications are subject to change. Refer to the official website for the latest version.
- Users must strictly adhere to specified conditions. Failures caused by misuse (overload, high temperature, incompatible circuits) are excluded from warranty.
- Contact technical support for customized validation in critical applications (medical devices, industrial control).
- This document is valid until December 31, 2026. Updates will be notified on the official website.
- For further clarification on technical specifications or application solutions, please contact us through official channels: