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Nanjing Tuowei Integrated Circuit Co., Ltd.

NanJing Top Power ASIC Corp.

data sheet

DATASHEET

TP4056

(1A Linear Li-Ion Battery Charger)

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Description The TP4056 is a complete constant current/constant voltage linear charger for single-cell Li-ion batteries. Its ESOP8/EMSOP8 package with heat sink on the bottom and low external component count make the TP4056 ideal for portable applications. TP4056 can work with USB power supply and adapter power supply. No external blocking diode is required due to the internal PMOSFET architecture coupled with an anti-reverse charging circuit. Thermal feedback automatically regulates charge current to limit die temperature during high power operation or high ambient temperature conditions. The charging voltage is fixed at 4.2V, while the charging current can be programmed externally with a single resistor. When the charge current drops to 1/10 of the set value after reaching the final float voltage, the TP4056 will automatically terminate the charge cycle.

When the input voltage (AC adapter or USB power supply) is removed, TP4056 automatically enters a low current state, reducing the battery leakage current to less than 2uA. The TP4056 can also be placed in shutdown mode when powered, reducing the supply current to 55uA. Other features of the TP4056 include battery temperature sensing, undervoltage lockout, automatic recharge, and two LED status pins to indicate the end of charging. Features Programmable Charge Current Up to 1000mA No MOSFET, Sense Resistor or Blocking Diode Required for Single-Cell Li-Ion Batteries in ESOP Package

linear charger

Constant current/constant voltage operation with thermal regulation to maximize charge rate without risk of overheating

4.2V Preset Charge Voltage with ±1% Accuracy

Charge Current Monitor Output for Battery Gauge Automatic Recharging Dual Charge Status Outputs, No Battery and Fault Status Display

·C/10 charge termination

·The supply current in standby mode is 55uA

·2.9V trickle charge ·Soft start limits the inrush current ·Battery temperature monitoring function

·Using 8-pin ESOP/EMSOP package.

application

·Mobile phone, PDA

·MP3, MP4 player ·Digital camera ·Electronic dictionary

·GPS

· Portable equipment, various chargers

Absolute maximum rating

Input power supply voltage (VCC): -0.3V to 8V

PROG: -0.3V to VCC+0.3V

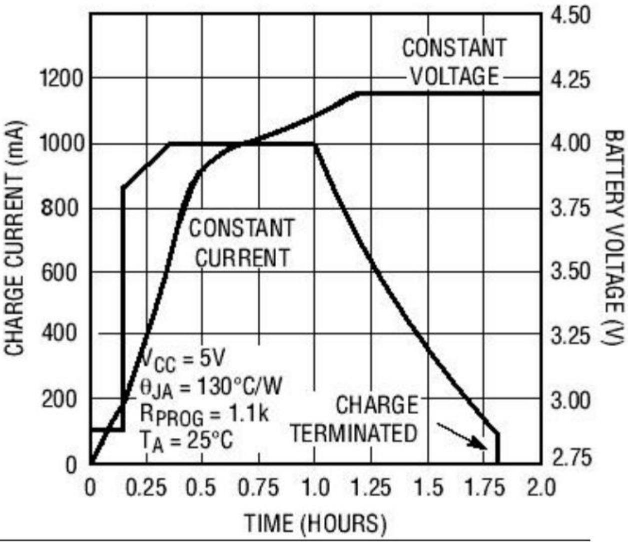
·BATÿ-0.3Vÿ7V

· $\overline{CHRG}$ ÿ-0.3Vÿ10V

· $\overline{STDBY}$: -0.3Vÿ10V TEMP: -0.3Vÿ10V CE: -0.3Vÿ10V BAT short circuit duration: continuous

BAT pin current: 1200mA PROG pin current: 1200uA Maximum junction temperature: 145ÿ ·Working environment temperature range: -40ÿÿ85ÿ ·Storage temperature range: -65ÿÿ125ÿ ·Lead temperature (soldering time 10 seconds): 260ÿ

Full charge cycle (1000mAh battery)



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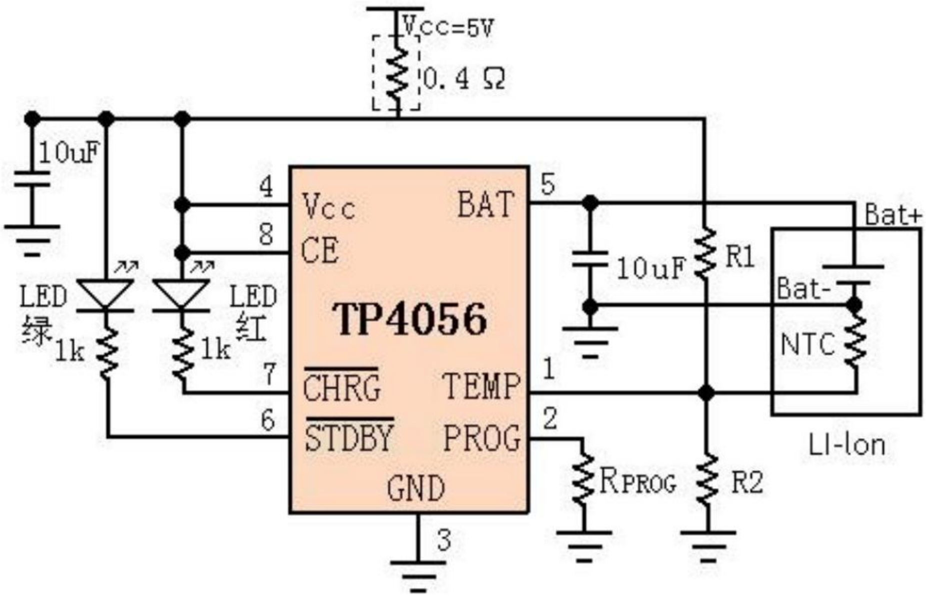
typical application



Packaging/Ordering Information

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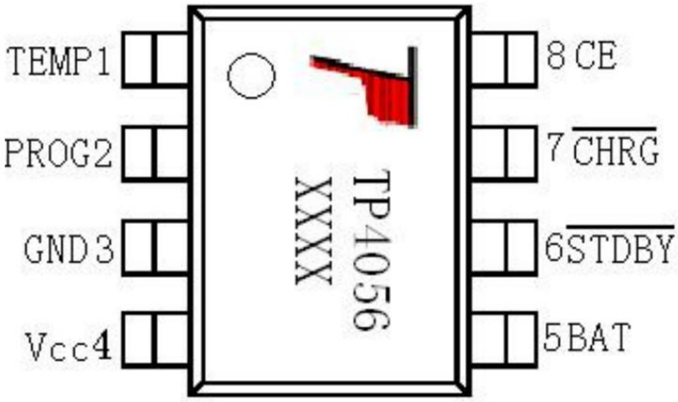
<tr><td rowspan="6">
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<tr><td>Physical picture</td></tr>
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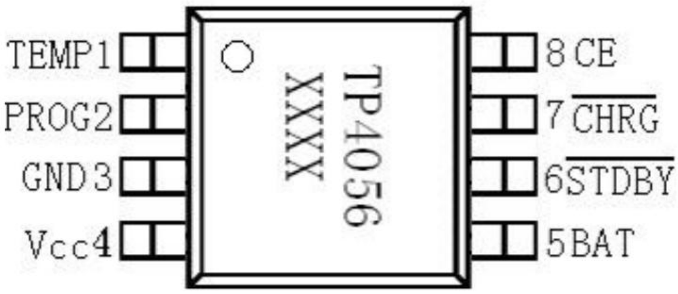
<tr><td rowspan="6">
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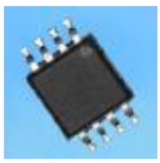
<tr><td></td></tr>
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electrical characteristics

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

symbol	parameter	condition		Min	Typ	Max	Unit
VCC	Input supply voltage		• 4.0		5	8.0	IN
ICC	Input power current	Charging mode, RPROG=1.2K	•		150	500	ÿA
		Standby Mode (Charge Termination)	•		55	100	ÿA
		shutdown mode (RPROG not connected,	•		55	100	ÿA
		VCC<VBAT, or VCC<VUV)			55	100	
VFLOAL	stable output (float charge) voltage	0ÿÿTAÿ85ÿÿ		4ÿ158	4ÿ2	4ÿ242	V
DIFFERENT	BAT pin current: (Current mode test conditions are VBAT=4.0V)	RPROG=2.4K, current mode	•	450	500	550	
		RPROG=1.2K, current mode	•	950	1000	1050	mAmA
		Standby mode, VBAT=4.2V	•	0	ÿ2.5	ÿ6	ÿA
		Shutdown mode (RPROG not connected)			±1	±2	ÿA
		Sleep mode, VCC=0V			ÿ1	ÿ2	ÿA
ITRIKL	Trickle charge current	VBAT<VTRIKLÿRPROG=1.2K • 120			130	140	mA
VTRIKL	Trickle Charge Threshold Voltage	RPROG=1.2K, VBAT rises		2.8	2.9	3.0	IN
VTRHYS	Trickle Charge Hysteresis Voltage	RPROG=1.2K		60	80	100	mV
VUV	VCC undervoltage lockout threshold	from VCC low to high	• 3.5		3.7	3.9	IN
VUVHYS	VCC Undervoltage Lockout Hysteresis		• 150		200	300	mV
VASD	VCC-VBAT blocking threshold voltage	VCC from low to high		60	100	140	
		VCC from high to low		5	30	50	mVmV
ITERM	C/10 termination current threshold	RPROG=2.4K	•	60	70	80	
		RPROG=1.2K	•	120	130	140	mAmA
VPROG	PROG pin voltage	RPROG=1.2K, current mode • 0.9			1.0	1.1	IN
vchrg	CHRG pin output low voltage	I CHRG =5mA			0.3	0.6	IN
VSTDBY	STDBY pin output low level	I STDBY =5mA			0.3	0.6	IN
VTEMP-H	TEMP pin high-side flip voltage				80	82	%Vcc
VTEMP-L	TEMP pin low-side flip voltage			43	45		%Vcc
ÿVRECHRG	recharge battery threshold voltage	VFLOAT-VRECHRG		100	150	200	mV
Junction temperature in TLIM limited temperature mode					145		ÿ
RON	Power FET "on" resistance (between VCC and BAT)				650		mÿ
tss	soft start time	IBAT=0 to IBAT=1200V/RPROG			20		ÿs
tRECHARGE	recharge comparator filter time	VBAT high to low		0.8	1.8	4	ms
tTERM	Terminate Comparator Filter Time	IBAT falls below ICHG /10		0.8	1.8	4	ms
PROG	PROG pin pull-up current				2.0		ÿA

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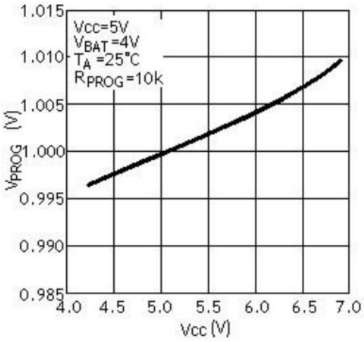
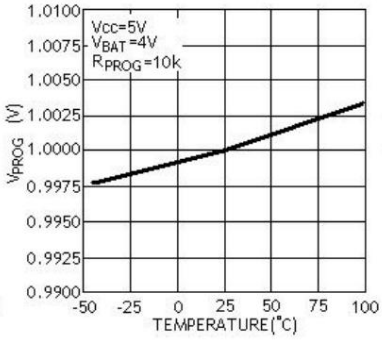
Typical Performance Characteristics

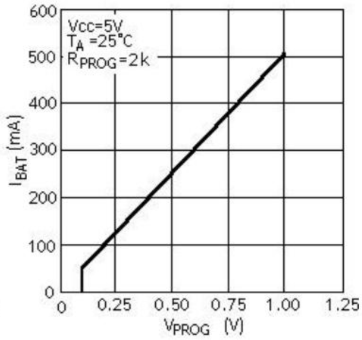
The relationship between PROG pin voltage and supply voltage in constant current mode



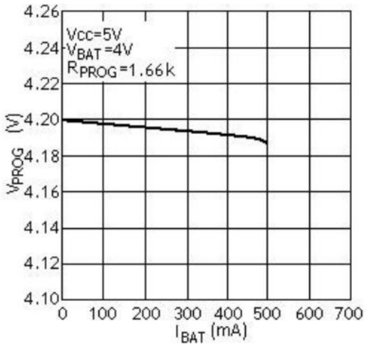
PROG Pin Voltage vs. Temperature Curve



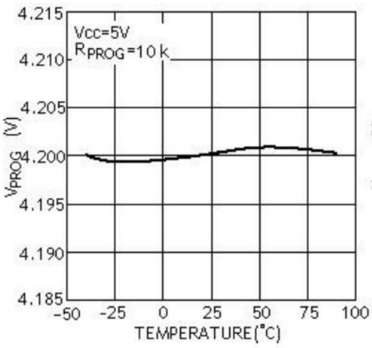
Relationship Curve of Charging Current vs. PROG Pin Voltage



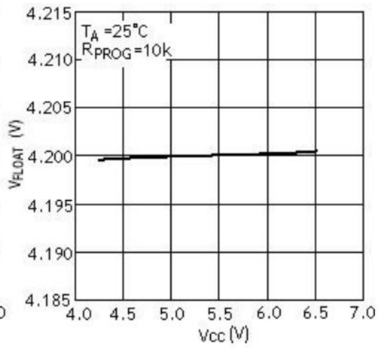
The relationship curve between stable output (float charge) voltage and charging current



Stable output (float charge) voltage versus temperature curve



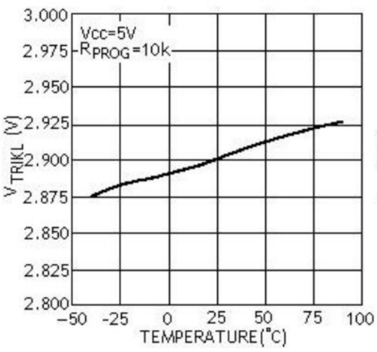
The relationship curve between stable output (float charge) voltage and voltage

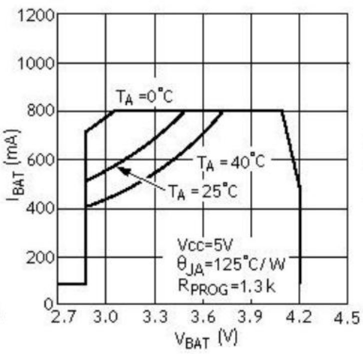


Relationship between trickle charge threshold and temperature Relationship curve between charging current and battery

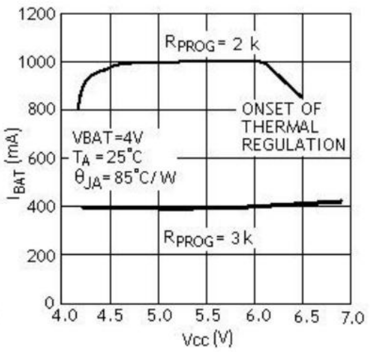
voltage

curve

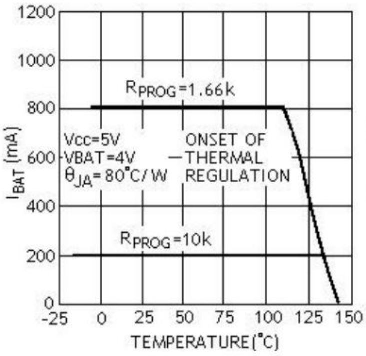




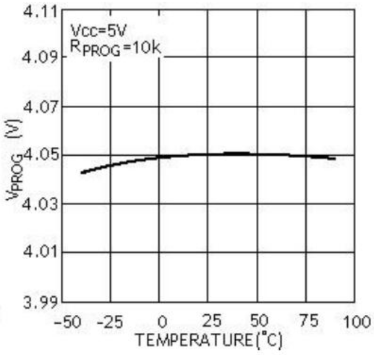
The relationship curve of charging current and power supply voltage

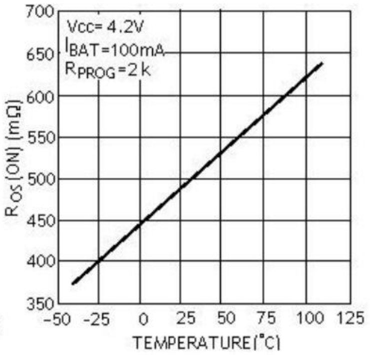


The relationship curve between charging current and ambient temperature



Recharge Voltage Threshold vs. Temperature Off Power FET "ON" Resistance vs. Temperature Curve





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pin function

TEMP (pin 1): battery temperature detection input. Connect the TEMP pin to the output of the battery's NTC sensor. If the voltage of the TEMP pin is less than 45% of the input voltage or greater than 80% of the input voltage, it means that the battery temperature is too low or too high, and the charging is suspended. If TEMP is directly connected to GND, the battery temperature detection function is cancelled, and other charging functions are normal.

PROG (pin 2): Constant current charging current setting and charging current monitoring terminal. The charging current can be programmed by connecting an external resistor from the PROG pin to ground. In the pre-charging phase, the voltage of this pin is modulated at 0.1V; in the constant current charging phase, the voltage of this pin is fixed at 1V. In all modes of charging status, measuring the voltage of this pin can estimate the charging current according to the following formula:

$$I_{ONE} = \frac{IN_{PROG}}{R_{PROG}} \times 1200$$

GND (Pin 3): Power ground.

Vcc (Pin 4): Input voltage positive input. The voltage of this pin is the working power of the internal circuit. When Vcc When the voltage difference with the BAT pin is less than 30mV, TP4056 will enter the low-power shutdown mode, and the current of the BAT pin is less than 2uA.

BAT (Pin 5): Battery connection terminal. Connect the positive terminal of the battery to this pin. When the chip is disabled or in sleep mode, the leakage current of the BAT pin is less than 2uA. The BAT pin provides charging current and a limited voltage of 4.2V to the battery.

$\overline{STDBY}$ (Pin 6): Battery charging completion indication terminal. When the battery is fully charged, it is pulled to a low level by the internal switch, indicating that the charging is complete. Otherwise, the pin will be in a high-impedance state.

$\overline{CHRG}$ (Pin 7) Charging status indication terminal for open-drain output. When the charger is charging the battery, the pin is pulled low by the internal switch, indicating that charging is in progress; otherwise, the pin is in a high-impedance state.

CE (pin 8) chip can be input. High input level will make TP4056 in normal working state; low input level will make TP4056 in charge prohibited state. CE pin can be driven by TTL level or CMOS level.

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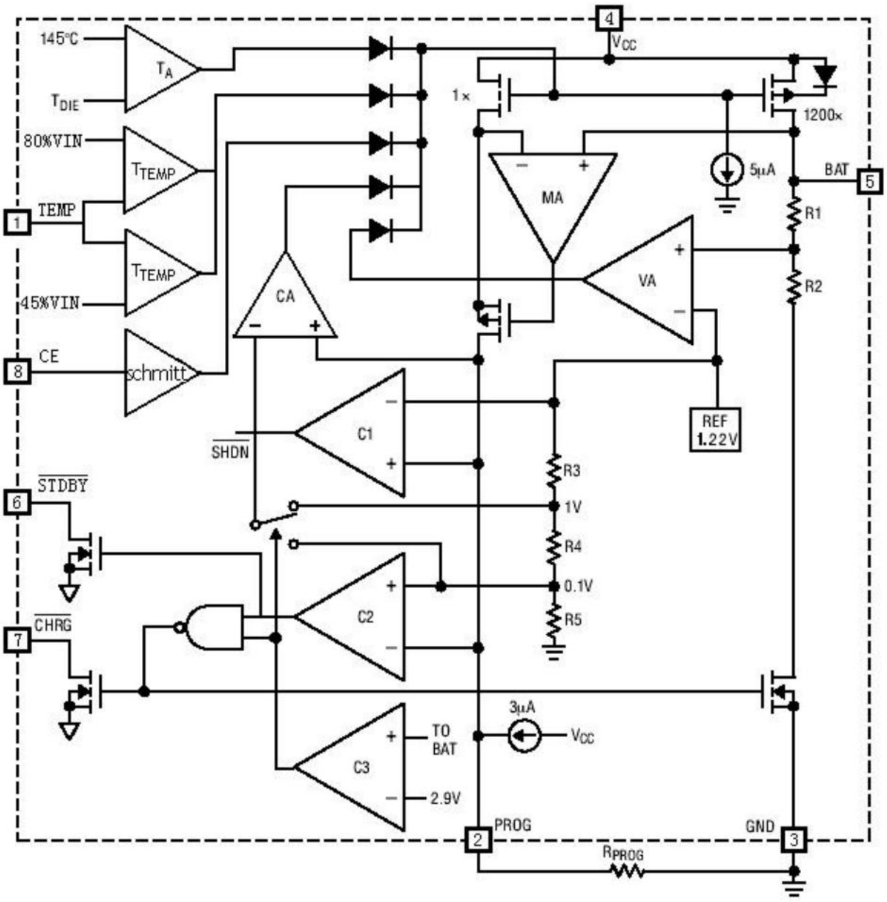
block diagram



working principle

TP4056 is a linear charger circuit specially designed for a lithium-ion or lithium-polymer battery. It uses the power transistor inside the chip to charge the battery with constant current and constant voltage. The charging current can be programmed and set by an external resistor, and the maximum continuous charging current can reach 1A, without additional blocking diodes and current detection resistors. The TP4056 includes two open-drain output status indication outputs, a charging status indication terminal and a battery fault status indication output terminal. CHRG The power management circuit inside the chip automatically reduces STDBY the charging current when the junction temperature of the chip exceeds 145°C. This function allows users to maximize the power handling capability of the chip without worrying about chip overheating and damage to the chip or external components. In this way, users don't need to consider the worst case when designing the charging current, but just design according to the typical situation, because in the worst case, TP4056 will automatically reduce the charging current. When the input voltage is greater than the low voltage detection threshold of the power supply and the chip enable input terminal is connected to a high level, the TP4056 starts to charge the battery, and the pin outputs a low level, indicating that the charging is in progress.

CHRG

Row. If the battery voltage is lower than 3V, the charger precharges the battery with a small current. When the battery voltage exceeds 3V, the charger adopts constant current mode to charge the battery, and the charging current is determined by the resistor RPROG between the PROG pin and GND . When the battery voltage is close to 4.2V, the charging current gradually decreases, and TP4056 enters the constant voltage charging mode. When the charging current decreases to the charging end threshold, the charging cycle ends, the terminal CHRG outputs a high-impedance state, and STDBY the terminal outputs a low potential. The end-of-charge threshold is 10% of the constant-current charge current. When the battery voltage drops below the recharge threshold, a new charge cycle is automatically started. The high-precision voltage reference source, error amplifier and resistor divider network inside the chip ensure that the accuracy of the battery terminal modulation voltage is within 1%, which meets the requirements of lithium-ion batteries and lithium-polymer batteries. When the input voltage is powered down or the input voltage is lower than the battery voltage, the charger enters a low-power sleep mode, and the current consumed by the battery terminal is less than 3uA, thereby increasing the standby time. If the enable input terminal CE is connected to low level, the charger stops charging.

Setting of charging current

The charging current is obtained using a connection between the PROG pin and ground

Resistors between to set. The setting resistor and charging current are calculated using the following formula: Determine the resistor value according to the required charging charging current,

$$R_{PROG} = \frac{1200}{I_{ONE}} \quad \text{(error ±10\%)}$$

In customer applications, RPROG of appropriate size can be selected according to requirements

The relationship between RPROG and charging current can be determined by referring to the following table:

RPROG (k)	IBAT (mA)
30	50
20	70
10	130
5	250
4	300
3	400
2	580
1.6	690
1.4	780
1.2	900
1.1	1000

charge termination

The charge cycle is terminated when the charge current drops to 1/10 of the set value after reaching the final float voltage. This condition is detected by monitoring the PROG pin with an internal filtered comparator. Charging is terminated when the PROG pin voltage drops below 100mV for longer than *t* (typically 1.8ms). The charging current is locked off, and the TP4056 enters standby mode, where the input supply current drops to 55μA. (Note: C/ *TERM* 10 termination is disabled in trickle charge and thermal limit modes).

While charging, transient loads on the BAT pin cause the PROG pin voltage to briefly drop below 100mV between DC charge current drops to 1/10 of the programmed value. The 1.8ms filter time (t) on the termination comparator ensures an *TERM* Transient loads will not cause premature termination of the charge cycle. Once the average charge current drops below 1/10 of the set value, the TP4056 terminates the charge cycle and stops supplying any current through the BAT pin. In this state, all loads on the BAT pin must be powered by the battery. In standby mode, TP4056 continuously monitors the BAT pin voltage. If the voltage on this pin drops to 4.05V then the

Below the charge voltage *threshold (VRECHRG),* another charge cycle begins and current is supplied to the battery again.

Figure 1 shows the state diagram for a typical charging cycle.

charge status indicator

TP4056 has two open-drain status indication outputs, $\overline{CHRG}$ and $\overline{STDBY}$. When the charger is in the charging state, $\overline{CHRG}$ it is pulled low, and in other states, it $\overline{CHRG}$ is in a high-impedance state. When the temperature of the battery is outside the normal temperature range, the pins output a high-impedance state. When $\overline{CHRG}$ and $\overline{STDBY}$ using the typical connection method of TEMP terminal, when the battery is not connected to the charger, it indicates a fault state: both the red light and the green light are not on. When the TEMP terminal is connected to GND, the battery temperature detection does not work. When the battery is not connected to the charger When , the output pulse signal $\overline{CHRG}$ indicates that no battery is installed. When the external capacitance of the BAT pin of the battery connection terminal is 10uF, the flashing frequency is $\overline{CHRG}$ about 1-4 seconds. When the status indication function is not used, connect the unused status indication output terminal to the ground. charging

	red light $\overline{CHRG}$	green light $\overline{STDBY}$
The battery is fully	Bright	off
charged, the battery is	off	Bright
undervoltage, the battery temperature is too high, too low, etc., or there is no battery connected. (used by TEMP)	off	off
BAT is connected to 10u capacitor, no battery (TEMP=GND)	Green light on, red light flashing T=1-4 S	

heat limit

If the die temperature rises above a preset value of approximately 140°C, an internal thermal feedback loop will reduce the programmed charge current until it reaches zero above 150°C. This feature prevents the TP4056 from overheating and allows the user to increase the upper limit of a given board's power handling capability without risking damage to the TP4056. Under the premise of guaranteeing that the charger will automatically reduce the current under worst-case conditions, the charging current can be set according to the typical (not worst-case) ambient temperature.

Battery temperature monitoring

In order to prevent the battery from being damaged by the temperature being too high or too low damage, TP4056 integrates a battery temperature monitoring circuit inside. Battery temperature monitoring is achieved by measuring the voltage of the TEMP pin, which is realized by the NTC thermistor in the battery and a resistor divider network, as shown in Figure 1.

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TP4056 compares the voltage of TEMP pin with the two thresholds VLOW and VHIGH inside the chip to confirm whether the temperature of the battery exceeds the normal range. Inside TP4056, VLOW is fixed at 45%×Vcc, and VHIGH is fixed at 80%×Vcc. If the voltage of the TEMP pin VTEMP<VLOW or VTEMP>VHIGH , it means that the temperature of the battery is too high or too low, and the charging process will be suspended; if the voltage of the TEMP pin VTEMP is between VLOW and VHIGH , the charging cycle will continue. If the **TEMP** pin is connected to ground, the battery temperature monitoring function will be disabled.

Determine the value of R1 and R2

The value of R1 and R2 depends on the temperature monitoring range of the battery and The resistance value of the thermistor is determined, and the examples are as follows:

Suppose the set battery temperature range is TLÿTH, (where TL<TH); the battery uses a negative temperature coefficient thermistor (NTC), RTL is its resistance at temperature TL, RTH is its resistance at temperature TH, then RTL>RTH, then , at the temperature TL, the voltage at the first pin TEMP is:

$$IN_{TEMPLE} \ \text{ÿ} \ \frac{R\,R \| _{TL}}{R\,ÿR2 \| _{TL}} \ \text{ÿ} \ COME$$

At the temperature TH, the voltage at the first pin TEMP is:

$$IN_{TEMP} \ \text{ÿ} \ \frac{R\,R \| _{TH}}{R\,ÿR2 \| _{TH}} \ \text{ÿ} \ COME$$

Then, by VTEMPL=VHIGH=k2×Vcc (k2=0.8)

VTEMPHÿVLOWÿk1×Vcc (k1=0.45)

Then it can be solved:

$$R1 \ \text{ÿ} \ \frac{RRKK_{TL\,TH}\,(\ _2 \quad _1)}{(RRKK_{TL} \quad _{TH})\ _{12}}$$

$$R2 \ \text{ÿ} \ \frac{RRKK_{TL\,TH}\,(\ _2 \quad _1)}{RKKKKKK_{TL}\,(\ _1 \quad _{12})\ _{TH}\,(\ _2 \quad _{12})}$$

Similarly, if the inside of the battery is a positive temperature coefficient (PTC) The thermistor, then >, we can calculate:

$$R1 \ \text{ÿ} \ \frac{RRKK_{TL\,TH}\,(\ _2 \quad _1)}{(RRKK_{TH} \quad _{TL})\ _{12}}$$

$$R2 \ \text{ÿ} \ \frac{RRKK_{TL\,TH}\,(\ _2 \quad _1)}{RKKKKKK_{TH}\,(\ _1 \quad _{12})\ _{TL}\,(\ _2 \quad _{12})}$$

From the above derivation, it can be seen that the temperature to be set The range has nothing to do with the power supply voltage Vcc, only with R1, R2, RTH and RTL are related; among them, RTH and RTL can be obtained by consulting relevant battery manuals or through experimental tests.

In practical applications, if you only care about the temperature characteristics of one end, such as overheating protection, then R2 can be used instead of R1. The derivation of R1 also becomes simple, so I won't repeat it here.

undervoltage lockout

An internal undervoltage lockout circuit monitors the input voltage and keeps the charger in shutdown until Vcc rises above the undervoltage lockout threshold. The UVLO circuit will keep the charger in shutdown mode. If the UVLO comparator trips, the charger will not exit shutdown mode until Vcc rises 100mV above the battery voltage.

manual shutdown

At any time during the charging cycle, the TP4056 can be placed in shutdown mode by setting the CE terminal low or removing RPROG (thus floating the PROG pin). This reduces battery drain current to less than 2µA and supply current to less than 55µA. A new charging cycle can be started by resetting the CE terminal to a high potential or connecting a setting resistor. If the TP4056 is in UVLO mode, the CHRG and pins are in a high-impedance state: either Vcc is less than 100mV above the BAT pin voltage, or insufficient voltage is applied to the Vcc pin. STDBY

auto restart

Once the charge cycle is terminated, the TP4056 immediately employs a) one with a filter time of 1.8ms (t *RECHARGE* the comparator to continuously monitor the voltage on the BAT pin. When the battery voltage drops below 4.05V (roughly corresponding to 80% to 90% of battery capacity), the charging cycle starts again. This ensures that the battery is maintained at (or close to) a fully charged state and eliminates the need for periodic charge cycle initiation. During the recharge cycle, the CHRG pin output enters a strong pull-down state.

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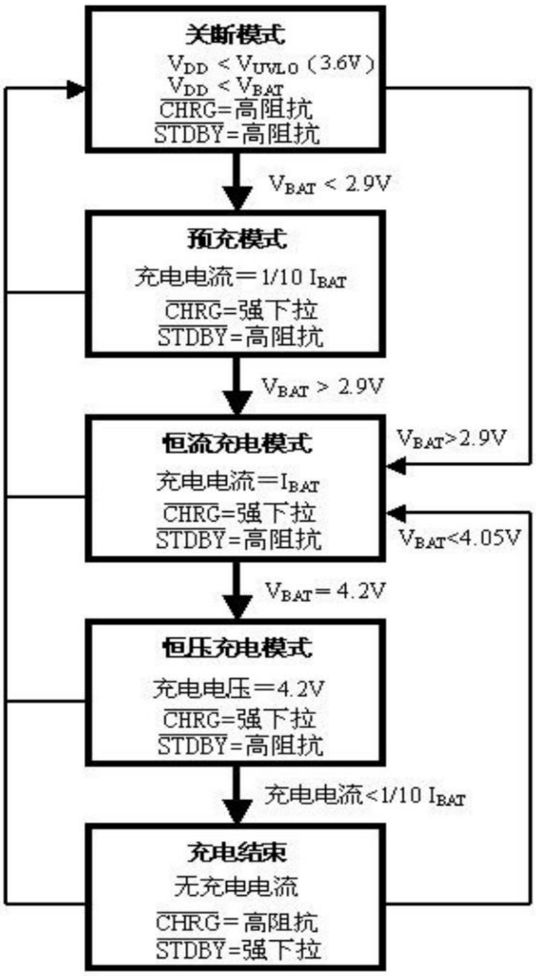

Figure 1: State Diagram of a Typical Charging Cycle

stability considerations

In constant current mode, the PROG pin is in the feedback loop, not the battery. The stability of constant current mode is affected by the impedance of PROG pin. When there is no additional capacitance on the PROG pin, it will reduce the maximum allowable resistance value of the programming resistor. The pole frequency on the PROG pin should be kept at CPROG, then the following formula can be used to calculate the maximum resistor value of RPROG:

$$R_{PROG} \; ÿ \; \frac{1}{2 \pi \cdot 10^{5} \cdot C_{PROG}}$$

For the user, they may be more interested in the charging current rather than the transient current. For example, if a switching power supply running in low current mode is connected in parallel with a battery, the average current drawn from the BAT pin is usually more important than the transient current pulses. In this case, a simple RC filter can be used on the PROG pin to measure the average battery current (as shown in Figure 2). A 10k resistor is added between the PROG pin and the filter capacitor for stability.

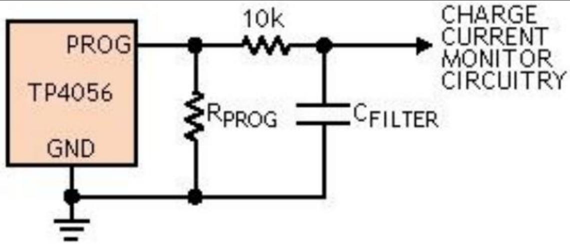

Figure 2: Isolation of capacitive loads and filter circuits on the **PROG** pin

Power loss

The conditions under which the TP4056 reduces the charging current due to thermal feedback can be estimated from the power loss in the IC. Almost all of this power loss is generated by the internal MOSFETs -- this can be approximated by: *P* ÿ *(V* ÿ*V*) • *I* CC ONE ONE

In the formula, PD is the dissipated power, VCC is the input power supply voltage, VBAT is the battery voltage, and IBAT is the charging current. When thermal feedback begins to protect the IC, the ambient temperature is approximately:

145 *TA* ÿ *C PD* 145 ÿ AND

TA ÿ ÿ *C VCC* (*VBAT*) • *I* • BAT ME ÿ

example: Through programming, a TP4056 that obtains working power from a 5V power supply provides a full-scale current of 800mA to a discharged lithium-ion battery with a voltage of 3.75V. Assuming ÿ AND 150°C/W (see board layout considerations), when the TP4056 starts to reduce the charging current, the ambient temperature is approximately: (5 3.75)

[illegible] 145 can be approximated by the following formula:

$$I_{ONE} \; ÿ \; \frac{145 \; ÿ \; C \; T_{A}}{(V_{CC} \; V_{BAT}) \cdot ÿ_{AND}}$$

As discussed in the Theory of Operation section, when thermal feedback reduces the charge current, the voltage on the PROG pin decreases proportionally. It is important to remember that the worst thermal conditions do not need to be considered in the TP4056 application design, because the IC will automatically reduce power consumption when the junction temperature reaches around 145°C. hot consideration

Due to the small form factor of the ESOP8/EMSOP8 package, a thermally well-designed PC board layout is required.

It is very important to maximize the available charging current. The thermal path used to dissipate the heat generated by the IC runs from the die to the lead frame and through the heat sink on the bottom to the copper surface of the PC board. The copper side of the PC board is the heat sink. The copper area where the heat sink is connected should be as wide as possible and extend out to a larger copper area to spread the heat into the surrounding environment. Vias to the inner or backside copper circuit layers are also useful in improving the overall thermal performance of the charger. Other heat sources on the board that are not related to the charger must also be considered when designing the PC board layout because they will have an impact on the overall temperature rise and the maximum charge current.

increase thermal regulation current

Reducing the voltage drop across the internal MOSFET can significantly reduce power dissipation in the IC. This has the effect of increasing the current delivered to the battery during thermal regulation. One countermeasure is to dissipate some of the power through an external component such as a resistor or diode. Example: Through programming, a TP4056 that obtains working power from a 5V AC adapter sets a full-scale charging current of 800mA to a discharge lithium-ion battery with a voltage of 3.75V. Assuming 125°C/W, at an ambient temperature of 25°C

$ÿ_{AND}$

Under the condition, the charging current is approximated as:

$$I_{ONE} \; ÿ \; \frac{145 \; ÿ \; C \; C \;\; 25 \; ÿ}{(5 \;\; 3.75)\; 125 / C \;\; W \; V \;\; ÿ} \; ÿ \; 768\; mA$$

On-chip power dissipation can be reduced by reducing the voltage across a resistor in series with the 5-V wall adapter as shown in Figure 3, thereby increasing the thermally regulated charge current:

$$I_{ONE} \; ÿ \; \frac{145 \; ÿ \; C \; C \;\; 25 \; ÿ}{(SOURCE\; V_S \;\; _{BAT\; CC\; BAT}) \bullet ÿ_{AND}}$$

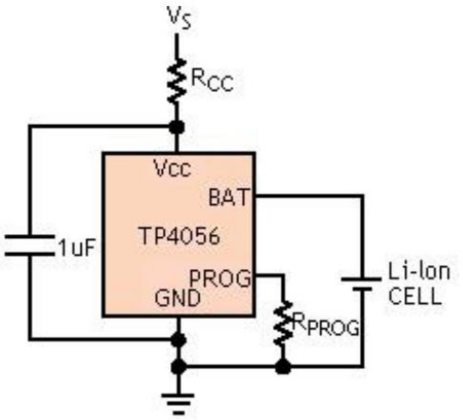

Figure 3: A circuit that maximizes thermal regulation mode charging and saving current

Using the quadratic equation, it can be found $I_{ONE}^{2} \; ÿ$

$$I_{ONE} \; ÿ \; \frac{(V_S V_{ONE}) \; \sqrt{(V_S V_{ONE})^2 \;\; 4\, R_{CC} \; \frac{(145 \; ÿ \; C\, T_A)}{ÿ_{AND}}}}{2\, R_{CC}}$$

ÿ RCC=0.25ÿÿVS=5VÿVBAT=3.75VÿTA=25ÿ

and $ÿ_{AND}$ ÿ 125°C/W , we can calculate the thermally adjusted

Charging current: IBATÿ948mA, the results show that the structure can output 800MA full charge at a higher ambient temperature.

While this application can deliver more power to the battery and shorten charge time in thermal regulation mode, in voltage mode it has the potential to actually prolong charge if VCC becomes low enough for the TP4056 to be in dropout time. Figure 4 shows how this circuit causes the voltage to drop as the RCC gets larger. This technique works best when the RCC value is minimized in order to keep the component size small and avoid voltage drop . Remember to choose a resistor with sufficient power handling capability.

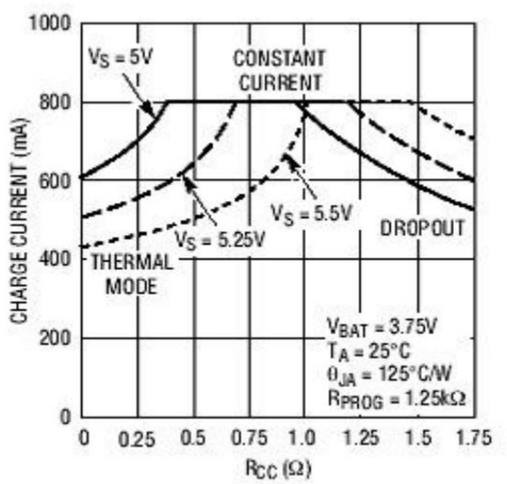

图4：充电电流与 R_{CC} 的关系曲线

VCC bypass capacitor

Various types of capacitors can be used for input bypassing. However, care must be taken when using multilayer ceramic capacitors. Due to the self-resonant and high-Q characteristics of some types of ceramic capacitors, high voltage transients may be generated during certain start-up conditions, such as connecting the charger input to a live power supply. Adding a 1.5ÿ resistor in series with the X5R ceramic capacitor will minimize startup voltage transients.

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Charging Current Soft Start

The TP4056 includes a soft-start circuit to minimize inrush current at the beginning of a charge cycle. When a charge cycle is initiated, the charge current will ramp from 0 to full-scale full-scale value in about 20µs. This serves to minimize transient current loads on the power supply during start-up.

Reverse Polarity Input Voltage Protection

In some applications, reverse polarity voltage protection on VCC is required. If the supply voltage is high enough, a series blocking diode can be used. In other cases where dropout must be kept low, a P-channel MOSFET can be used (as shown in Figure 5).

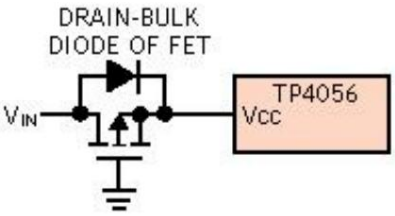

Figure 5: Low-loss input reverse polarity protection

USB and AC Adapter Power

The TP4056 allows charging from a wall adapter or a USB port. Figure 6 shows an example of how to combine a wall adapter with a USB power input. A P-channel MOSFET (MP1) is used to prevent the signal from being reversed into the USB port when the wall adapter is plugged in, and a Schottky diode (D1) is used to prevent loss of USB power through the 1K pull-down resistor .

Generally, a wall adapter can supply much more current than a USB port with a current limit of 500mA. Therefore, an N-channel MOSFET (MN1) and an additional 10K programming resistor can be used to increase the charge current to 600mA when the wall adapter is plugged in.

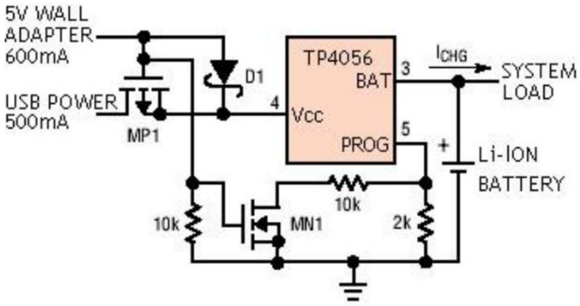

Figure 6: Combination of AC adapter and USB power supply

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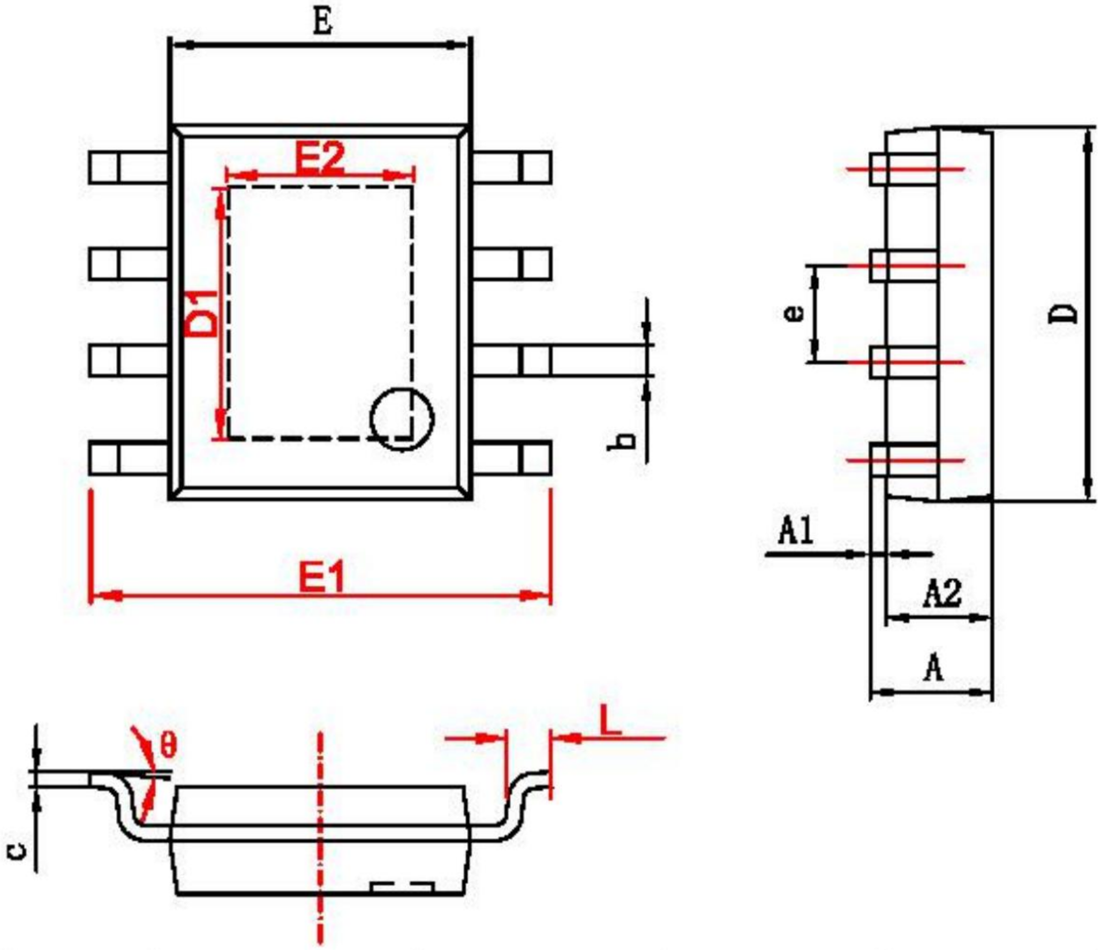
Package Description

8 - pin **ESOP** package (in **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°

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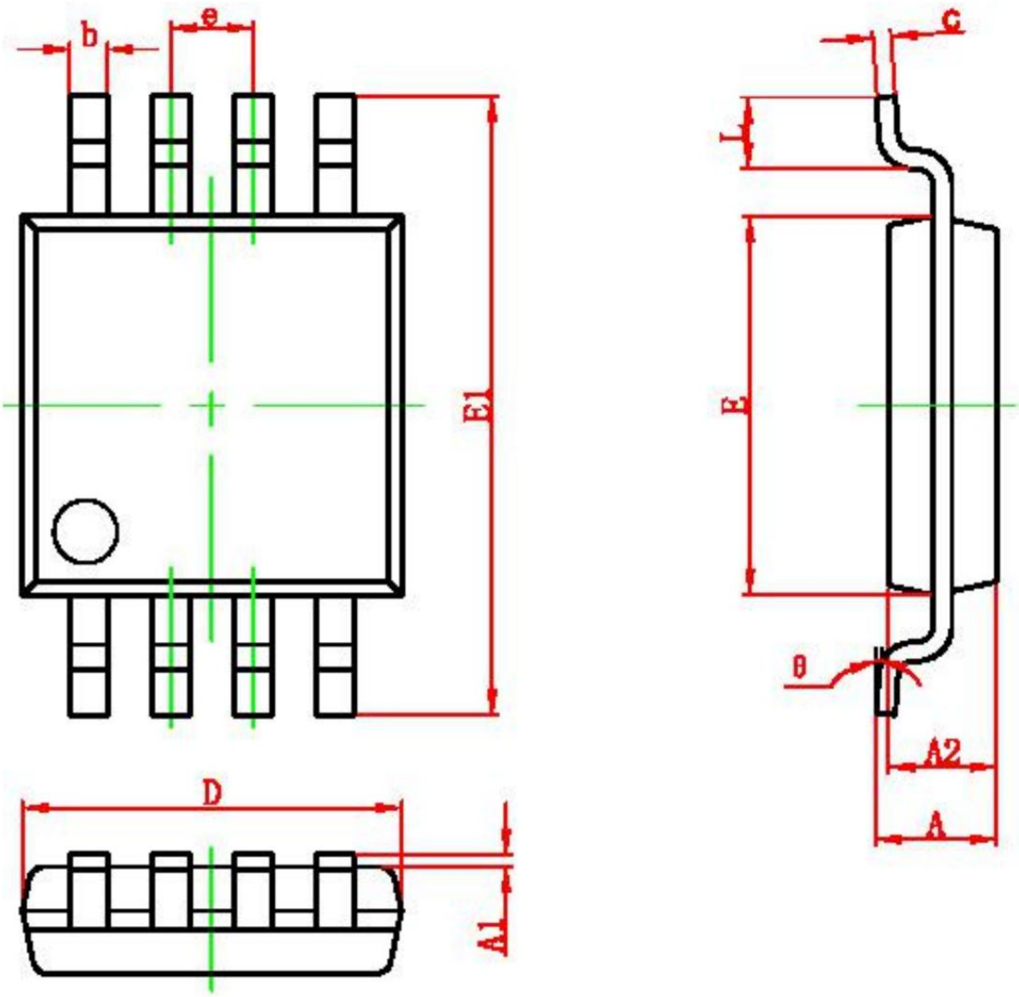
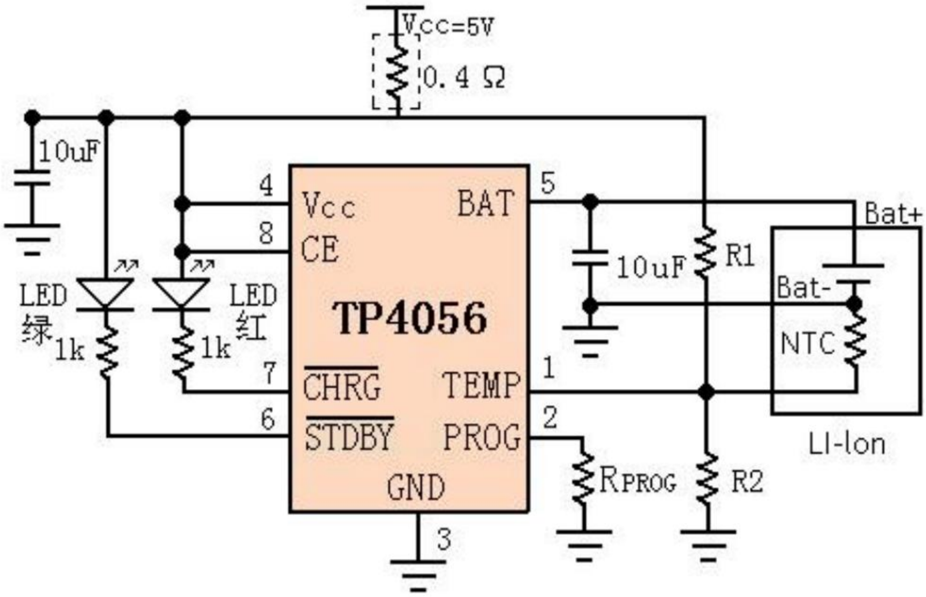
8 - pin **EMSOP** package (in **mm)**



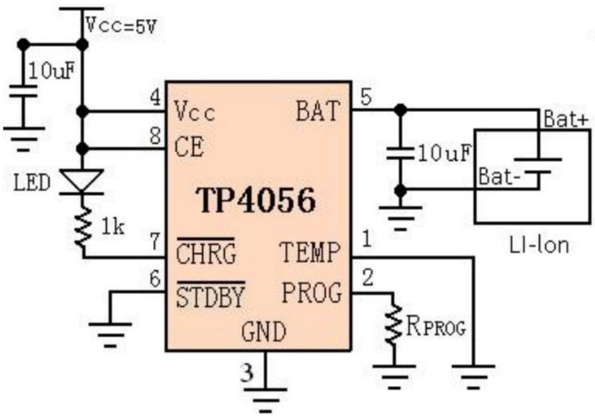
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0. 820	1. 100	0. 032	0. 043
A1	0. 020	0. 150	0. 001	0. 006
A2	0. 750	0. 950	0. 030	0. 037
b	0. 250	0. 380	0. 010	0. 015
c	0. 090	0. 230	0. 004	0. 009
D	2. 900	3. 100	0. 114	0. 122
e	0.650(BSC)		0.026(BSC)	
E	2. 900	3. 100	0. 114	0. 122
E1	4. 750	5. 050	0. 187	0. 199
L	0. 400	0. 800	0. 016	0. 031
θ	0°	6°	0°	6°

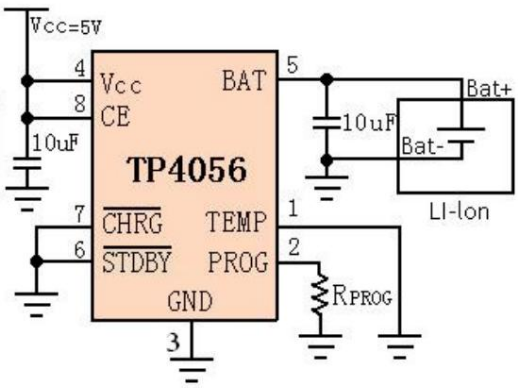
typical application



Suitable for applications requiring battery temperature detection function, abnormal battery

temperature indication and charging status indication



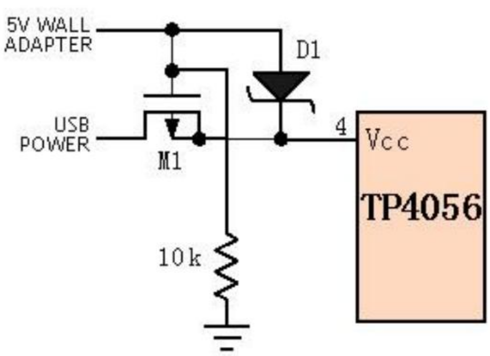


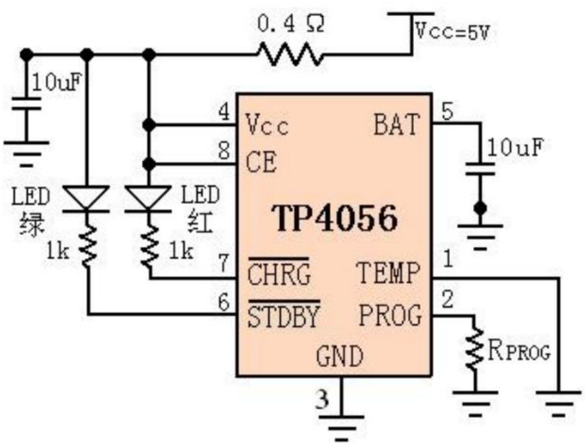
Suitable for charging status indication, not required

Application of battery temperature monitoring function

Ideal for applications requiring neither charge status indication nor

battery temperature monitoring





Suitable for simultaneous application of USB interface and wall adapter charging The charging status is indicated by a red LED, and the charging end status is

indicated by a green LED to increase heat dissipation power resistance

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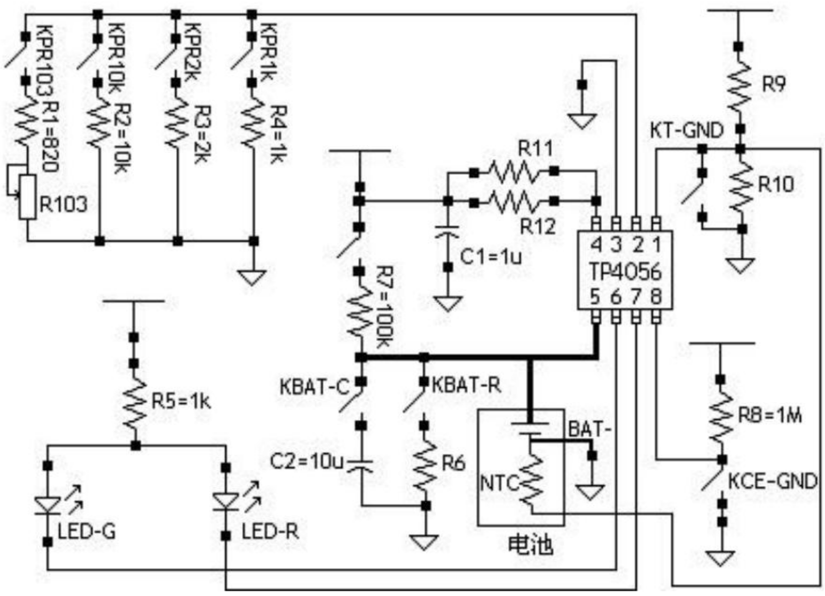
TP4056 Precautions and **DEMO** Board Manual

1. Precautions for use of TP4056: 1. TP4056 is packaged in ESOP8/EMSOP8. During use, the heat sink at the bottom and the PCB board should be welded well. The heat dissipation area at the bottom needs to add through holes, and it is better to have a large area of copper foil for heat dissipation. Multi-layer PCB with sufficient via holes has a good effect on heat dissipation, and poor heat dissipation may cause the charging current to be reduced due to temperature protection. Appropriate via holes are added to the heat dissipation part on the back of ESOP8/EMSOP8, which also facilitates manual soldering (you can pour solder from the via holes on the back to solder the heat dissipation surface reliably).

2. TP4056 is used in high current charging (above 700mA), in order to shorten the charging time, it is necessary to increase the heat dissipation resistor (R11, R12 as shown in the figure below), and the resistance range is 0.2ÿ0.5ÿ. The customer selects the appropriate resistor size according to the usage.

3. In the application of TP4056, the position of the 10u capacitor at the BAT terminal is preferably close to the BAT terminal of the chip, and should not be too far away.

4. During the TP4056 test, the BAT terminal should be directly connected to the battery, and the ammeter cannot be connected in series. The ammeter can be connected to the Vcc terminal. 5. In order to ensure reliable use in various situations and prevent chip damage caused by peak and burr voltages, it is recommended to connect a 0.1u ceramic capacitor to the BAT terminal and the power input terminal, and to be very close to the TP4056 chip when wiring. 2. TP4056 DEMO board circuit diagram



3. Function demonstration instructions: (Working environment: power supply voltage 5V, ambient temperature 25°C.) 1. Set the charging current. (The user can adjust the potentiometer to select the required charging current) Close KPR1k, close KPR1.2k, close KPR2k, close KPR10k, close KPR103, 2. Setting indicator lights, red and green double lights indicate: charging status charging status battery full status under Voltage, battery temperature is too high, too low, no battery and other failure states (the TEMP terminal is normally connected)

RPROG=1k	1300mA
RPROG=1.2k	1000mA
RPROG=2k	600mA
RPROG=10k	130mA
RPROG=0.82kÿ10.5k	120mAÿ1300mA

	Indicator status Red
	light is on, green light is off,
	red light is off, green light is
	on, red light is off, green light is off
The BAT terminal is connected to a 10u capacitor, no battery (the TEMP terminal is grounded)	Green light on, red light flashing

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3. Simulate the charge state closed

KPR10k, KBAT-C, KBAT-R, KT-GND

Connect a capacitor C2 and a resistor R6 to the BAT end to replace the lithium battery, simulating the charging state: the red light is on, and the green light is off.

Note: This state simulation is limited to power supply voltage less than or equal to 5V, please use a lithium battery for actual testing when it is greater than 5V.

Close KPR10k, KBAT-C, KT-GND

Connect a capacitor C2 to the BAT terminal to replace the lithium battery to simulate the state of charging completion: the green light is on and the red light is flashing. Note: Since the 10uF capacitor C2 is used instead of the lithium battery to simulate the fully charged state, the capacitor is slowly discharged after being fully charged, and when the capacitor voltage drops to the recharge threshold voltage of 4.05V, it will be automatically recharged, and the red light can be seen to flash periodically. 4. Simulate the BAT terminal voltage at the charging end

Close KPR10k, KBAT-C, KBAT-R, KT-GND to measure BAT terminal voltage. That is, the voltage at the end of charging is 4.2V ±1.5%.

5. If the customer needs to monitor the battery temperature, disconnect KT-GND, connect the TEMP terminal (pin 1, the connection hole has been reserved) of TP4056 to the lithium battery temperature monitoring terminal, and the customer can customize the size of R9 and R10 according to the actual situation and install them. If this function is not needed, just close KT-GND.

6. CE can only end. Close the switch KCE-GND, pull down the CE terminal to low level, the chip stops charging; open KCE-GND, The chip is charging normally.

7. Some customers do not want the red indicator light to flash when there is no lithium battery at the BAT terminal in the application. Close KBATUP, connect the BAT terminal to Vdd with a 100k resistor, and the green light is on, which can be used to indicate the standby state and does not affect normal charging. 8. Lithium battery charging Connect the positive pole of the lithium battery to the BAT terminal of the chip, and the negative pole to ground. If you need temperature monitoring function, please connect TEMP terminal (pin 1), otherwise close KT-GND. Set the required charging current and indicator light, disconnect KBATR, KCE-GND, and start charging.