1.Description

TP4056 is a high-performance single cell lithium-ion battery constant current/constant voltage linear charger. The TP4056 adopts the ESOP8 package with fewer peripheral components, making it very suitable for portable products and suitable for powering USB power supplies and adapter power supplies.

Based on the special internal MOSFET architecture and anti-reverse charging circuit, TP4056 does not require external detection resistors and isolation diodes. When the external ambient temperature is too high or in high-power applications, thermal feedback can adjust the charging current to reduce the chip temperature. The charging voltage is fixed at 4.2V, and the charging current can be set externally through a resistor. When the charging current drops to 1/10 of the set value after reaching the final floating charge voltage, the chip will terminate the charging cycle.

When the input voltage is disconnected, the TP4056 enters a sleep state and the battery leakage current drops below 1uA. The TP4056 can be set in shutdown mode, in which case the chip quiescent current drops to 35uA.

TP4056 also includes other features: battery temperature monitoring, undervoltage lockout, automatic recharge and two status pins to display charging and charge termination.

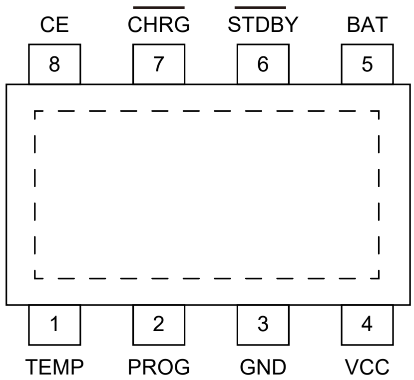
2.Characteristic

- Programmable charge current 1000mA
- No need for external MOSFETs, detection resistors, and isolation diodes
- Full linear charging for single lithium batteries packaged in esop8
- Constant-Current/Constant-Voltage Operation with Situations Thermal Regulation to Maximize Charge
- Rate Without Risk of Overheating Device
- Charge Current Monitor Output for Battery Level Sensing
- 4.2V PRE-CHARGE VOLTAGE WITH ±1% ACCURACY
- Automatic Recharge
- Charging current monitor output for battery level detection
- Dual Outputs for Charge Status, No Battery, and Fault Status
- C/10 charging termination
- The quiescent current in shutdown mode is 35uA
- 2.9V TRICKLE CHARGE
- Battery Temperature Monitoring
- Soft-Start Limits Inrush Current
- BAT INPUT ANTI-REVERSE CONNECTION PROTECTION
- 0V ACTIVATION

3.Application

- Mobile phones pda
- MP3 and MP4 players
- Chargers
- Digital Cameras
- Electronic Dictionaries
- Bluetooth, GPS navigation system
- Portable device
- TP4056 uses ESOP-8 package

4.Pinning Information

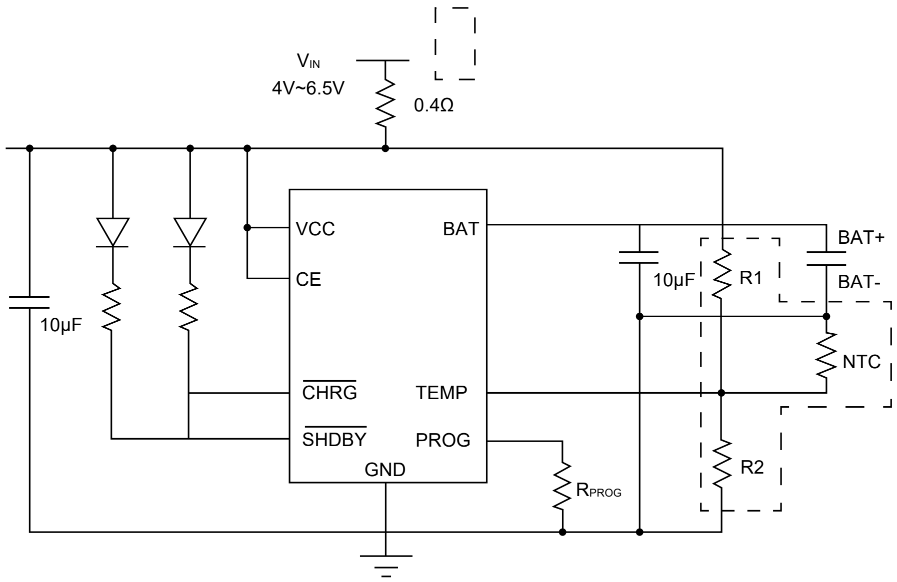


ESOP8

Pin Description

Pin Number	Pin Name	Describe
1	TEMP	Battery temperature detection input
2	PROG	Programmable constant current charging current setting terminal
3	GND	Ground end
4	VCC	Power supply terminal
5	BAT	Battery end
6	$\overline{\text{STDBY}}$	Battery charging completion indicator terminal
7	$\overline{\text{CHRG}}$	Battery charging indicator terminal
8	CE	Chip enable input terminal

5.Typical Applications



Among them, the dashed box indicates the R1/R2/NTC resistor part for battery temperature monitoring, which is optional. Alternatively, the TEMP pin can be directly grounded without monitoring the battery temperature.

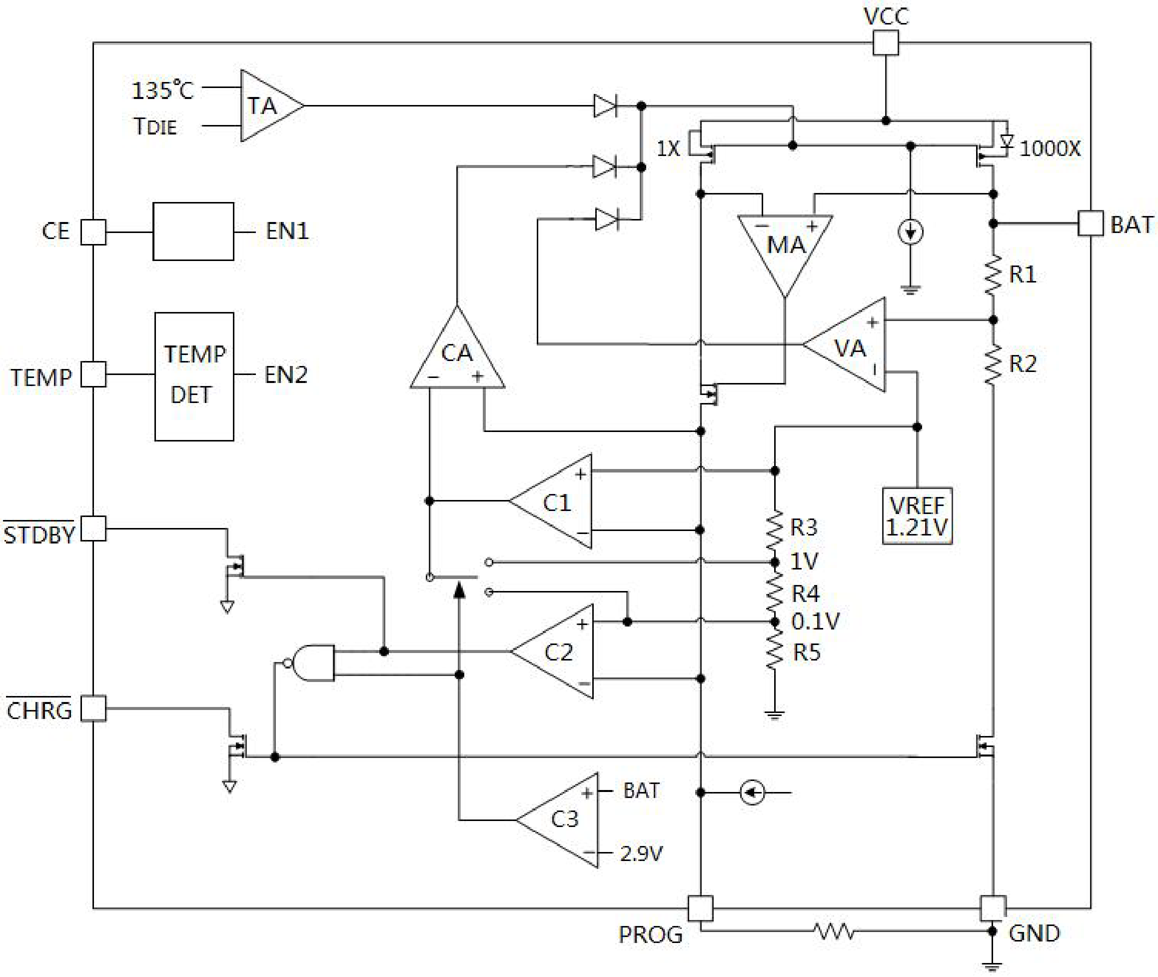
6.Maximum Ratings (Note)

Parameter	Rating	Units
VCC Terminal Voltage	-0.3 to 6.5	V
PROG, BAT, CE, TEMP Terminal Voltage	-0.3 to 6.5	V
CHRG Terminal Voltage	-0.3 to 8	V
Stdby Terminal Voltage	-0.3 to 8	V
Bat End Current	1.2	A
Prog Terminal Current	1.2	mA
Maximum Power Dissipation	1500	mW
Operating Ambient Temperature	-40 to 85	°C
Minimum/maximum Storage Temperature T_{STG}	-65 to 125	°C

7.ESD And Latch-up Level

Human body model esd level	4000V
Machine model esd level	400V
Latch-up Level	400mA

8.Structural Block Diagram



9.Electrical characteristics

If there is no special instructions, ambient temperature = 25°C, input voltage = 5V

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Input supply voltage	V_{CC}		4		6.5	V
Input supply current	I_{CC}	Charging mode (R_{PROG}=12k) (1)		240	500	μA
		standby mode (charge termination)		50	100	μA
		Stop mode (R_{PROG} not connected V_{CC}<V_{BAT}, V_{CC}<$V_{UV}I_O$)		35	70	μA
Output float voltage	V_{FLOAT}	0°C<T<85°C	4.17	4.2	4.263	V
Bat terminal charging current	I_{BAT}	Constant current mode, R_{PROG}=2.4k	465	500	535	mA
		Constant current mode, R_{PROG}=1.2k	930	1000	1070	mA
		Standby mode, V_{BAT}=4.2V	0	-2.5	-6	μA
		Stop mode		1	2	μA
		Battery reverse connection mode V_{BAT}=-4V		0.7		mA
		Sleep mode, V_{CC}=0V		0	1	μA
Trickle charge current	I_{TRIKL}	V_{BAT}<V_{TRIKL}, R_{PROG}=2.4K	40	50	60	mA
		V_{BAT}<V_{TRIKL}, R_{PROG}=1.2K	80	100	120	mA
Trickle charge threshold voltage	V_{TRIKL}	V_{BAT} RISES	2.8	2.9	3	V
Trickle charge hysteresis voltage	V_{TRHYS}	V_{BAT} FALLS	60	80	100	mV
VCC Undervoltage Lockout Voltage	V_{UVLO}	V_{CC} RISES	3.7	3.8	3.93	V
VCC Undervoltage Lockout Hysteresis Voltage	V_{UVHYS}	V_{CC} FALLS	150	200	300	mV
Manual shutdown threshold voltage	V_{MSD}	V_{PROG} RISES	1.15	1.21	1.3	V
		V_{PROG} FALLS	0.9	1	1.1	V
VCC -VBAT Lockout Voltage	V_{ASD}	V_{CC} RISES	70	100	140	mV
		V_{CC} FALLS	5	30	50	mV
C/10 Termination Current Limit (2)	I_{TERM}	R_{PROG}=1.2K	0.085	0.1	0.115	A
		R_{PROG}=2.4K	0.035	0.05	0.065	A

Parameter	Symbol	Conditions	Min	Typ	Max	Units
PROG Pin Voltage	V_{PROG}	Constant current mode, R_{PROG}=1.2k	0.93	1	1.07	V
CHRG Outputs Low Level	V_{CHRG}	I_{CHRG}=5mA		0.35	0.6	V
STDBY Outputs Low Level	V_{STDBY}	I_{STDBY}=5mA		0.35	0.6	V
Temp Pin High-end Flip Voltage	V_{TEMP_H}			80	83	%V_{CC}
Temp Pin Low-end Flip Voltage	V_{TEMP_L}		42	45		%V_{CC}
Recharge Battery Threshold Voltage	ΔV_{RECHG}	V_{FLOAT}-V_{RECHRG}		50	100	mV
Recharge Delay Time	t_{RECHG}	V_{BAT} from high to low	0.8	1.8	4	ms
Charge Termination Delay Time	t_{TERM}	I_{BAT} falls below I_{CHG}/10	0.63	1.4	3	ms
PROG PULL-UP Current	I_{PROG}			2		μA
CE END “HIGH" Level	V_{CEH}		1.3			V
CE END "LOW" Level	V_{CEL}				0.7	V

Note

(1): At this time, it is in the charging state, I_{CC}=I_{VCC}- I_{BAT}

(2): Here c/10 termination current threshold refers to the ratio of termination current to constant current charging current.

10.1 Typical characteristic

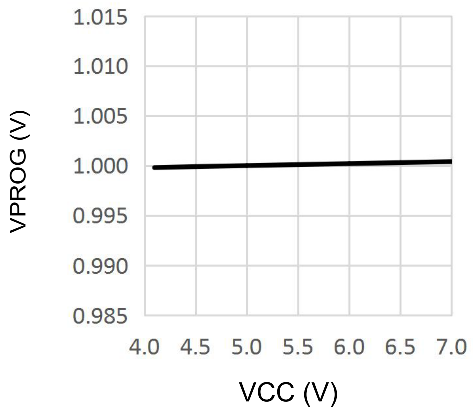


Figure 1: PROG Pin In Constant Current Mode The Relationship Curve Between Voltage And Power Supply Voltage

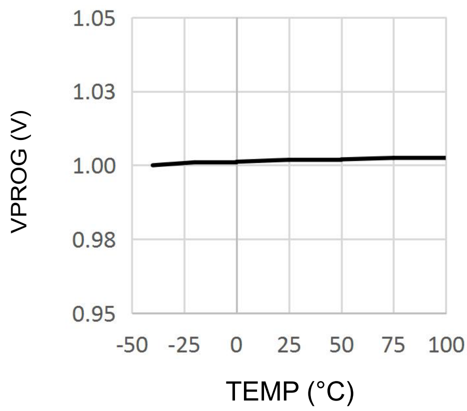


Figure 2: PROG Pin Voltage VS. Temperature Relationship Curve

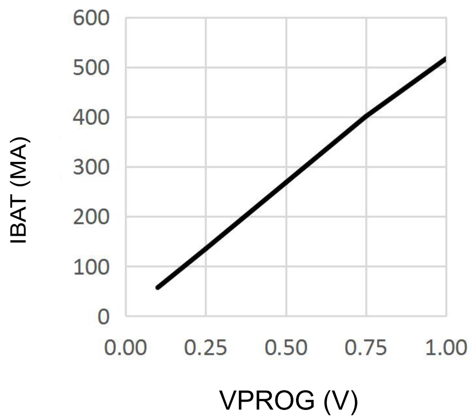


Figure 3: Charging Current VS. PROG Pin Voltage Relationship Curve

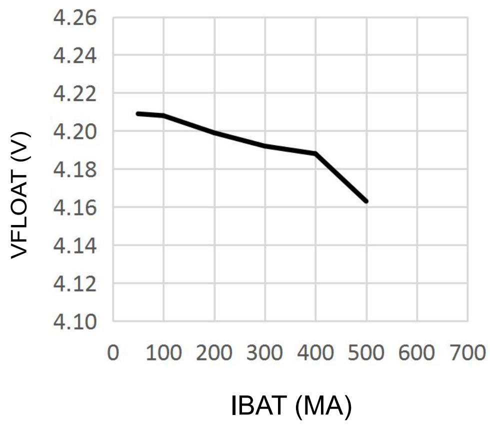


Figure 4: Stable output (float charging) voltage and Relationship curve of charging current

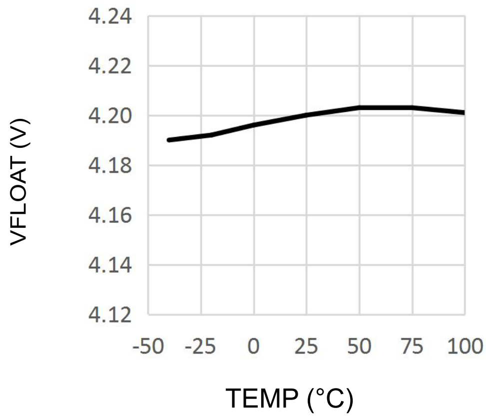


Figure 5: Stable output (float charging) voltage and Temperature relationship curve

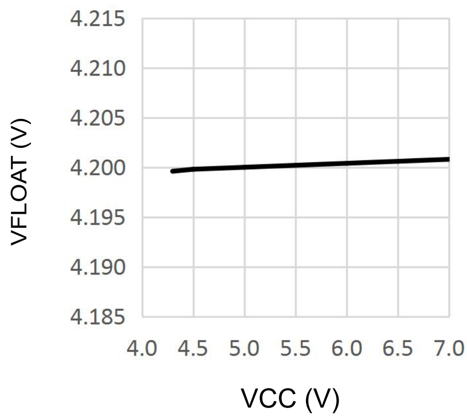


Figure 6: Stable output (float charging) voltage and Relationship curve of power supply voltage

10.2 Typical characteristic

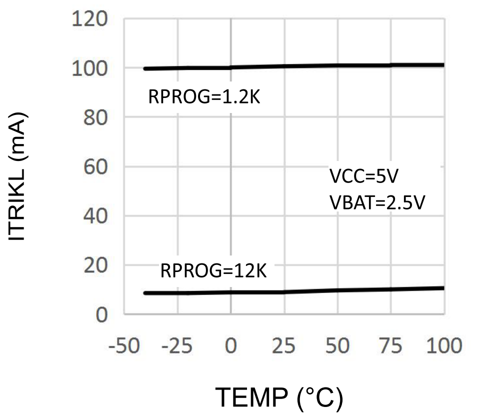


Figure 7: The relationship between trickle charging current and temperature Relationship curve

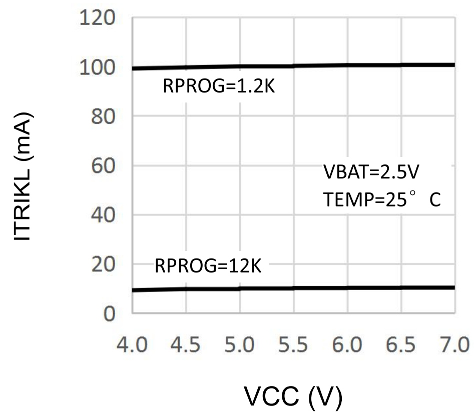


Figure 8: The relationship between trickle charging current and power supply voltage Relationship curve

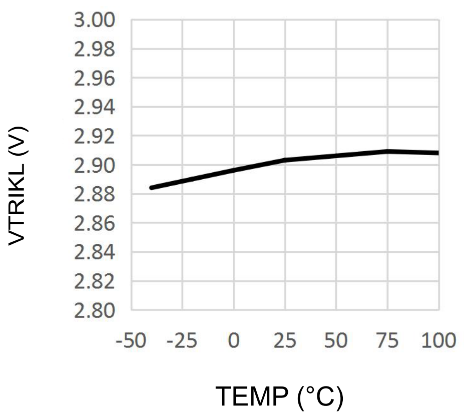


Figure 9: The threshold voltage of trickle charging and Temperature relationship

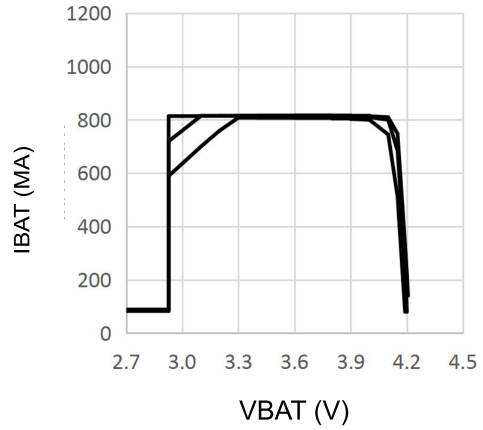


Figure 10: Charging current and battery voltage Relationship curve

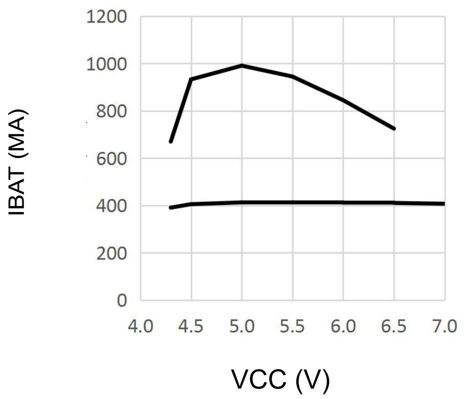


Figure 11: Charging current and power supply voltage curve between charging current and ambient temperature

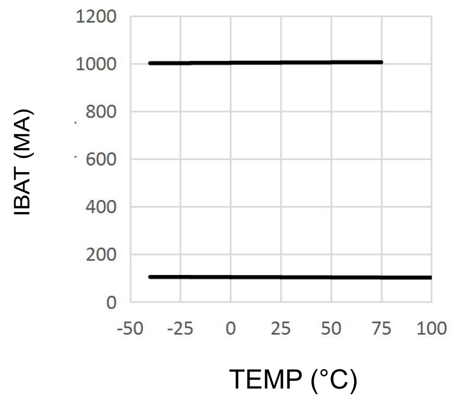


Figure 12: The relationship Relationship curve

10.3 Typical characteristic

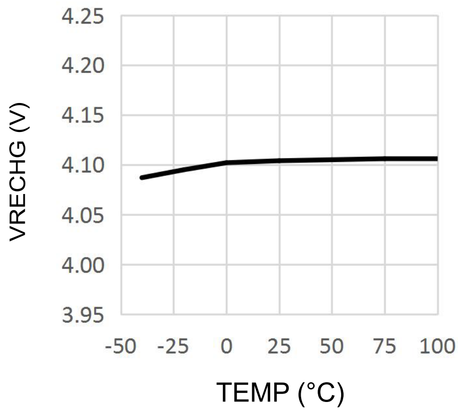


Figure 13: Rechargeable battery threshold voltage and Temperature relationship curve

11.Usage User Manual

TP4056 is a linear charger designed specifically for lithium-ion batteries. It uses the power MOSFET inside the chip to charge the battery with constant current/constant voltage. The charging current can be determined by external resistor programming, and the maximum charging current can reach 1000mA. TP4056 has two open-drain output status indication output terminals, the charging status indication terminal CHRG and the battery charging completion indication output terminal STDBY. The power tube circuit inside the chip automatically reduces the charging current when the junction temperature of the chip exceeds 135℃. This function allows users to maximize the use of chip charging without worrying about chip overheating and damage to the chip or external components.

Working Principle

When the input voltage exceeds the UVLO detection threshold and the chip enable input terminal CE is connected to a high level, TP4056 starts charging the battery. If the battery voltage is below 2.9V, the charger will pre charge the battery with a small current. When the battery voltage exceeds 2.9V, the charger adopts a constant current mode to charge the battery, and the charging current is determined by the resistance between the prog terminal and the gnd terminal. When the battery voltage approaches 4.2v, the charging current gradually decreases and TP4056 enters constant voltage charging mode. When the charging current decreases to the charging end threshold, the charging cycle ends.

The charge end threshold is 1/10 of the constant current charge current. When the battery voltage drops below the recharge threshold, a new charge cycle automatically starts. The high-precision voltage reference source, error amplifier and resistor divider network inside the chip ensure that the accuracy of the BAT modulation voltage is within 1%, meeting the requirements of lithium-ion and lithium polymer batteries. When the input voltage is powered off or the input voltage is lower than the battery voltage, the charger enters shutdown mode, and the current consumed by the battery terminal is less than 2uA, thereby increasing the standby time.

If the enable input terminal ce is connected to a low level, the charger stops charging.

Charging Current Setting

The charging current is set by a resistor connected between the prog pin and ground. Determine the resistor value according to the required charging current, and use the following formula to calculate the setting resistor and charging current:

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

$$R_{PROG}= \frac{1200}{I_{BAT}} \text{ (Error ± 10\%)}$$

R_{PROG}(K)	I_{BAT}(mA)
1.2	1000
2.4	500
3	400
4	300
6	200
12	100

Charging Termination

When the charging current drops to 1/10 of the set value after reaching the final float voltage, the charging cycle is terminated. This condition is detected by monitoring the PROG terminal with an internal filter comparator. When the voltage at the PROG terminal drops below 100mV for more than 1.8ms, charging is terminated and the TP4056 enters standby mode, at which time the input power supply current drops to about 50uA.

During charging, transient loads on the BAT terminal can cause the PROG terminal voltage to drop below 100mV briefly before the DC charging current drops to 1/10 of the set value. The 1.8ms delay time of the comparator ensures that transient loads of this nature do not cause the charging cycle to terminate prematurely. Once the average charging current drops below 1/10 of the set value, the TP4056 centralized charging cycle and stops providing any current through the BAT terminal. In this state, all loads on the BAT terminal must be powered by the battery.

Charging Status Indication

TP4056 has two open-drain status indication outputs chrg and stdby. When the charger is in the charging state, chrg is pulled to a low level, and in other states chrg is in a high impedance state; when the battery is charged, stdby is pulled to a low level, and in other states stdby is in a high impedance state.

When the battery is not connected to the charger, chrg flashes to indicate that the battery is not installed.

Charging Status	CHRG	STDBY
Charging	bright	extinguish
Charge Complete	extinguish	bright
Undervoltage, battery temperature too high, too low Fault conditions, or no battery connected (temp use)	extinguish	extinguish
1uF capacitor connected to the BAT terminal, no battery	Flashing (frequency about 20Hz)	bright

Thermal Limitation

If the chip temperature rises above 135 c, an internal thermal feedback loop will reduce the set charging current. This function prevents TP4056 from overheating and allows the user to increase the upper limit of the power handling capability of a given circuit board while reducing the risk of damaging TP4056.

Battery Temperature Detection

In order to prevent damage to the battery caused by excessively high or low temperatures, the TP4056 has an internal battery temperature monitoring circuit. 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 the typical application diagram. 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 charging is suspended.

If the temp pin is directly connected to gnd, the battery temperature detection function is canceled and other charging functions are normal.

Determine the relationship between r1 and r2price

The values of r1 and r2 should be determined based on the temperature monitoring range of the battery and the resistance value of the thermistor. Here is an example to illustrate:

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.

$$V_{TEMPL} = \frac{R2||R_{TL}}{R1+R2||R_{TL}} \times VIN$$

Therefore, RTL>rth. At temperature tl, the voltage at the first pin temp is:

At temperature th, the voltage of the first pin temp is:

$$V_{TEMPH} = \frac{R2||R_{TH}}{R1+R2||R_{TH}} \times VIN$$

Then, vtempl vhigh k 2 vcc (k 2 0.8)

$V_{TEMPH}=V_{LOW}=K_1 \times V_{CC}$ (K_1=0.45)

Then it can be solved that:

$$R1= \frac{R_{TL}R_{TH}(K_2-K_1)}{(R_{TL}-R_{TH})K_1K_2} \qquad R2= \frac{R_{TL}R_{TH}(K_2-K_1)}{R_{TL}(K_1-K_1K_2)-R_{TH}(K_2-K_1K_2)}$$

Similarly, if the battery has a positive temperature coefficient (ptc) thermistor, then >, we can calculate:

$$R1= \frac{R_{TL}R_{TH}(K_2-K_1)}{(R_{TH}-R_{TL})K_1K_2} \qquad R2= \frac{R_{TL}R_{TH}(K_2-K_1)}{R_{TH}(K_1-K_1K_2)-R_{TL}(K_2-K_1K_2)}$$

From the above derivation, it can be seen that the temperature range to be set is independent of the power supply voltage vcc, only related to r1, r2, rth, and rtl; Among them, rth and rtl can be obtained by consulting relevant battery manuals or through experimental testing.

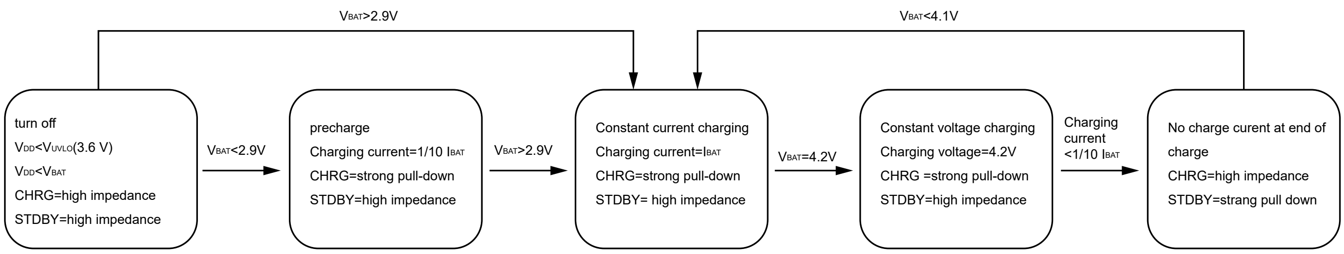
In practical applications, if we only focus on the temperature characteristics of one end, such as overheating protection, then r2 can be omitted and only r1 can be used. The derivation of r1 has also become simple and will not be repeated here.

Undervoltage locking

TP4056 has an internal undervoltage lockout circuit to monitor the input voltage and keep the chip in shutdown mode before VCC rises to the undervoltage lockout threshold voltage. When the VCC voltage rises to 3.8V, the chip exits UVLO and starts normal operation. The UVLO hysteresis voltage when VCC drops is 200mV.

Automatic Charging Cycle

After the battery voltage reaches the floating charge voltage and the charging cycle is terminated, the TP4056 immediately monitors the BAT terminal voltage. When the BAT terminal voltage is lower than 4.1V, the charging cycle restarts. This ensures that the battery is maintained in a state close to full charge, while eliminating the need to start the periodic charging cycle.

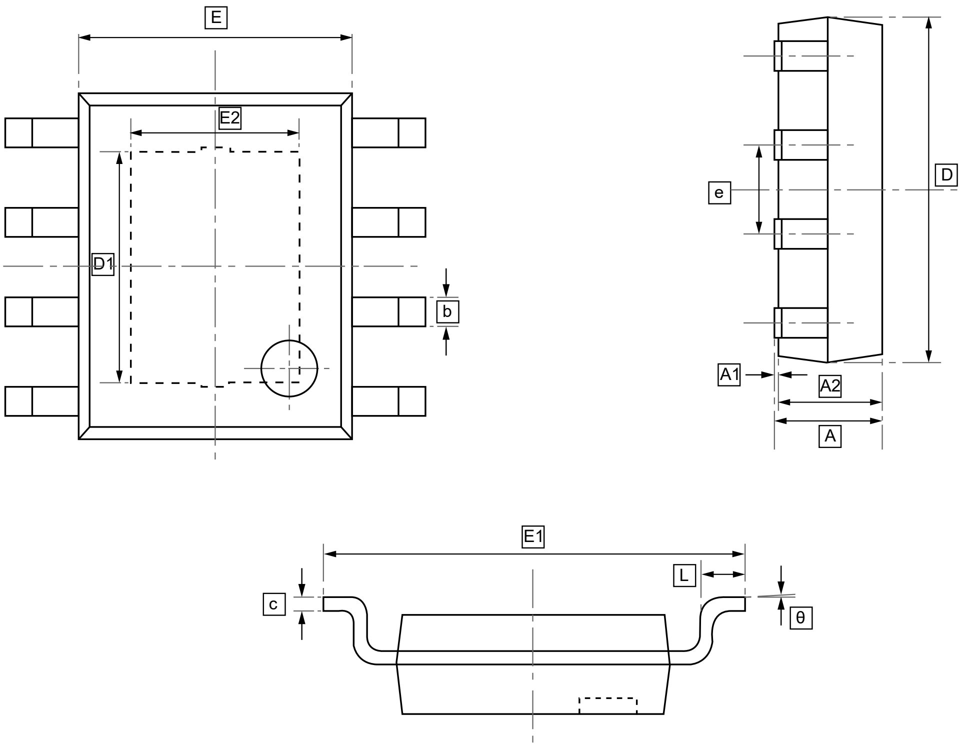


State diagram of a typical charging cycle

Battery Reverse Polarity Protection

TP4056 has a lithium battery reverse connection protection function. When the positive and negative poles of the battery are reversely connected to the TP4056 voltage output BAT pin, TP4056 will stop and display a fault state, and there is no charging current. The charging indicator pin is in a high impedance state, and RLED is off. At this time, the reverse battery leakage current is less than 1mA. Connect the reverse battery correctly, and TP4056 automatically starts the charging cycle.

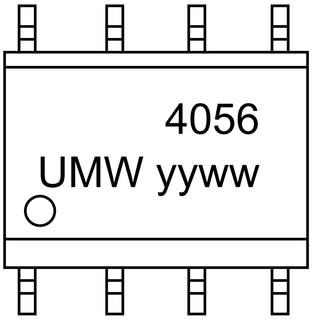
12.ESOP-8 Package Outline Dimensions



DIMENSIONS (mm are the original dimensions)

Symbol	A	A1	A2	b	c	D	D1	E	E1	E2	e	L	θ
Min	1.300	0.000	1.350	0.330	0.170	4.700	3.202	3.800	5.800	2.313	1.270	0.400	0°
Max	1.700	0.100	1.550	0.510	0.250	5.100	3.402	4.000	6.200	2.513	BSC	1.270	8°

13.Ordering Information



yy: Year Code
ww: Week Code

Order Code	Package	Base QTY	Delivery Mode
UMW TP4056	ESOP-8	4000	Tape and reel

14.Disclaimer

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