Shenzhen Fuman Microelectronics Co., Ltd.
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4056H(File No:S&CIC1103) 1ALinear lithium battery charging chip

1. Product description

4056HIt is a complete single-cell lithium-ion battery using constant current/constant voltage linear charging chip.MOSFETarchitecture, plus an anti-backflow circuit, so no external blocking diodes are required.

4056HThermal feedback automatically adjusts the charge current to limit the die temperature during high power operation or high ambient temperature conditions. The charging voltage is fixed at4.2V, while the charge current can be set externally with a resistor. When the charging current drops to the set value after reaching the final float voltage1/10 hour,4056HThe charging cycle will be automatically terminated.

4056HWith battery temperature detection,CEThe enable function can also monitor the charging current, has the characteristics of voltage detection, automatic cycle charging, and has two indicators for indicating charging, endingledstatus pin.

2. Features

- Gundam1000mAProgrammable charge current of
- no needMOSFET, sense resistor or reverse diode
- For single-cell Li-ion batteries, usingESOP8package
- Constant current/constant voltage mode operation, with thermal protection function
- Accuracy reaches±1%Accurate preset charging voltage
- The supply current in standby mode is50uA
- 2.9VTrickle charge voltage
- Soft-Start Limits Inrush Current
- Battery temperature monitoring function
- CEenable function

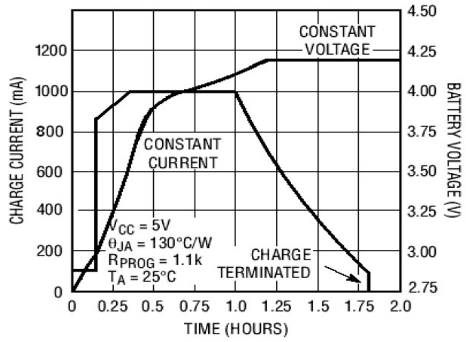
3. Product application

- mobile phone,PDA
- MP3,MP4player
- digital camera
- E-dictionary
- GPS
- Portable devices, various chargers

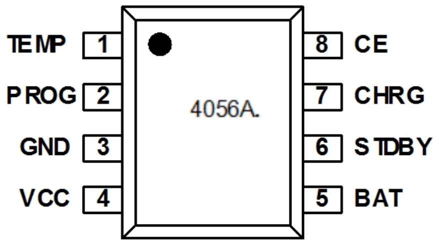
4. Absolute Maximum Ratings

- Input supply voltage (Vcc):-0.3V~7V
- PROG:-0.3V~ Vcc +0.3V
- BAT :-0.3V~7V
- CHRG :-0.3V~V
- STDBY:-0.3V~7V
- TEMP:-0.3V~7V
- BATCurrent:1000mA
- PROGPin current:800uA
- Maximum Junction Temperature:110°C
- Operating ambient temperature range:-40°C~85°C
- Storage temperature range:-65°C~125°C
- Pin temperature (soldering time ≦10second)260°C/W

Five, complete charging cycle (1000mAhBattery)



6. Packaging/ordering information and functions



- TEMP(pin1): battery temperature detection input terminal. WillTEMPpin receives currentNTCsensor output. ifTEMPpin voltage is less than the input voltage45%or greater than the input voltage80%, meaning the battery temperature is too low or too high, charging is suspended. ifTEMPdirectlyGND, the battery temperature detection function is canceled, and other charging functions are normal.
- PROG(pin2): constant current charging current setting and charging current monitoring terminal. fromPROGThe charge current can be programmed by connecting the pin to an external resistor to ground. During the precharge phase, the voltage of this pin is modulated at0.1V; During the constant current charging phase, the voltage of this pin is fixed at1V. In all modes of charging state, measuring the voltage of this pin can estimate the charging current according to the following formula:
- GND(pin3): power ground.
- VCC(pin4): Input voltage positive input terminal. The voltage of this pin is the working power of the internal circuit. whenVccandBATThe voltage difference between the pins is less than 30mVhour,4056Hwill enter a low-power shutdown mode, whenBATpin current is less than2uA.

$$I_{BAT} = \frac{V_{PROG}}{R_{PROG}} \times 1200$$

- BAT(pin5): battery connection terminal. Connect the positive terminal of the battery to this pin. When the chip is disabled from working or in sleep mode,BATThe leakage current of the pin is less than2uA.BATpin provides charging current to the battery and4.2Vlimit voltage.
- STDBY(pin6): indicating terminal of battery charging completion. When current charging is completeSTDBYPulled to low level by the internal switch, indicating that charging is complete. besides,STDBYThe pins will be in a high impedance state.
- GHRG(pin7) charge status indication terminal of open-drain output. When the charger charges the battery,CHRGThe pin is pulled low by the internal switch, indicating that charging is in progress; otherwiseCHRGThe pin is in a high impedance state.
- CE(pin8) chip can only be input. A high input level will enable4056Hin normal operation; low input levels enable4056HIn a state where charging is prohibited.CEpins can beTTLlevel orCMOSlevel driven.

Seven, electrical characteristics

Where table note●Indicates that the indicator is suitable for the entire operating temperature range, otherwise only refers toTA=25°C,Vcc=5V, unless otherwise noted.

symbol	parameter	condition		minimum	Typical value	maximum value	unit
VCC	Input supply voltage		●	4.5	5	5.5	V
ICC	Input supply current	charging mode,RPROG=1.2K Standby Mode (Charge Termination) stop mode (RPROGnot connected, VCC<VBAT,orVCC<VUV)	● ● ●		60 60 45	300	μA μA μA
VFLOAL	Stable output (float) voltage	0°C≤TA≤85°C,		4.16	4.2	4.28	V
		Shipping voltage grade: A grade 4.20-4.28V【Regular】; **B file 4.16-4.24V**【custom made】					
IBAT	BATPin current: (Current mode test conditions are VBAT=4.0V)	RPROG=1.2K, current mode VBAT=4.2V, standby mode stop mode (RPROGnot connected) sleep mode,VCC=0V	● ● ●	900	1000 - 2.5 +/-0.5 +/-1	1100 +/-5 +/-5 +/-5	mA uA μA μA
ITRIKL	Trickle Charge Current	VBAT<VTRIKLRPROG=1.2K	●		100		mA
VTRIKL	Trickle Charge Threshold Voltage	RPROG=1.2K,VBATrise		2.8	2.9	3.05	V
VUV	VCCUndervoltage Lockout Threshold	VCClow to high	●		3.8		V
VUVHYS	VCCUndervoltage Lockout Hysteresis	VCChigh to low	●		200		mV
VASD	VCC-VBATblocking threshold Voltage	VCClow to high VCCfrom high to low		60 5	100 30	100 30	mV mV
ITERM	C/10Termination Current Threshold	RPROG=1.2K	●	90	100	110	mA
VPROG	PROGpin voltage	RPROG=1.2K, current mode	●	0.9	1.0	1.1	V
VSTDBY	STDBYpin output low power flat	I STDBY = 5mA			0.3	0.6	V
VTEMP-H voltage rise	TEMPPin high side flip Voltage	VTEMPhigher than80-82% Vcc, close the charging valve.			80% 【4V】	82% 【4.1V】	Vcc
VTEMP-L voltage drop	TEMPPin low side flip Voltage	VTEMPlower than45-43% Vcc, close the charging valve.		43% 【2.15V】	45% 【2.25V】		Vcc
ΔVRECHRG	Rechargeable battery threshold voltage	VFLOAT-VRECHRG		3.95	4.0	4.05	V
TLIM	Thermal Protection Junction Temperature				145		°C

Notice:

1. Exceeding the maximum operating range may damage the chip.

2. Proper function is not guaranteed beyond device operating parameter limits.

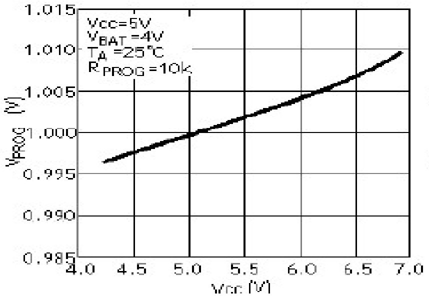
3. The supply current includes the PROG terminal current (about 100 uA) and does not include other currents delivered to the battery through the BAT terminal.

4. The charge termination current is generally 0.1 times the set charge current.

Eight, typical performance characteristics

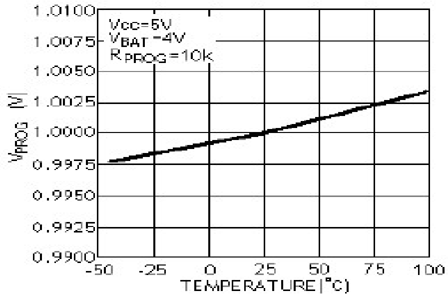
in constant current modePROGpin

The relationship between voltage and supply voltage



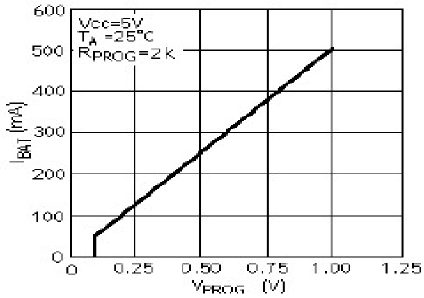
PROGpin voltage vs. temperature

Relationship lines



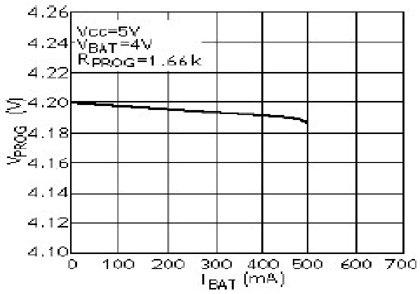
charging current withPROGpin power

pressure curve



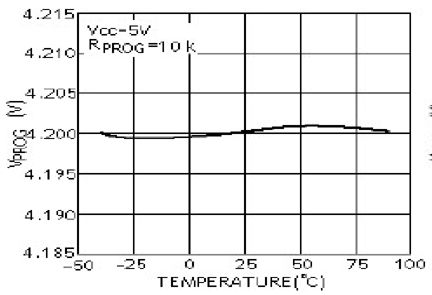
Stable output (float) voltage and charge

Electric current relationship curve



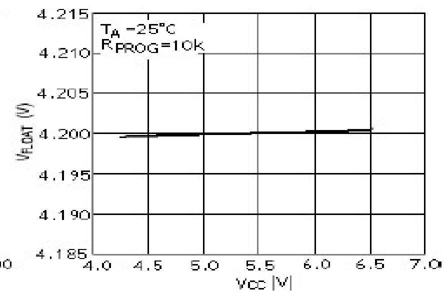
Stable output (float) voltage vs. temperature

degree curve

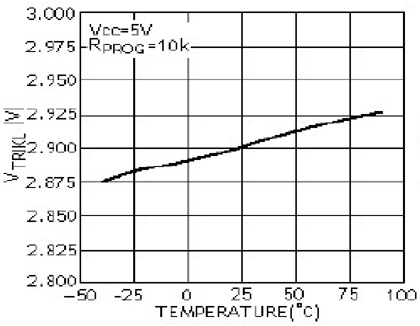


Stable output (float) voltage and power

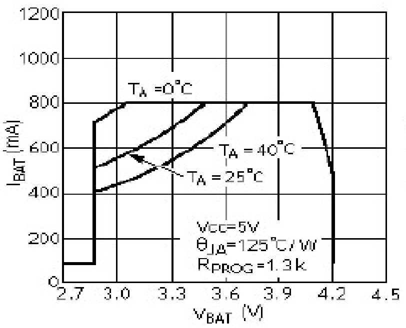
pressure curve



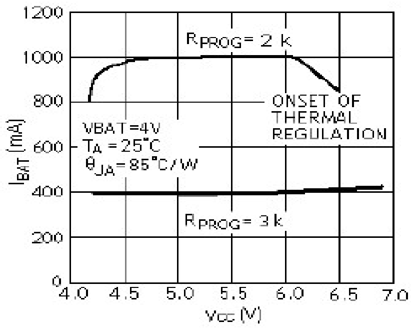
Trickle Charge Threshold vs Temperature



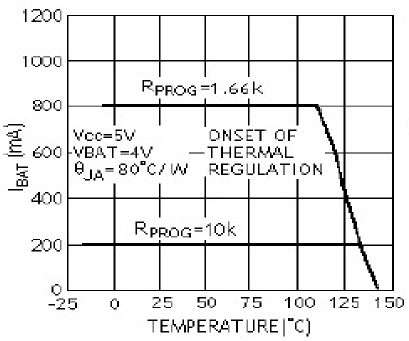
The relationship between charging current and battery voltage



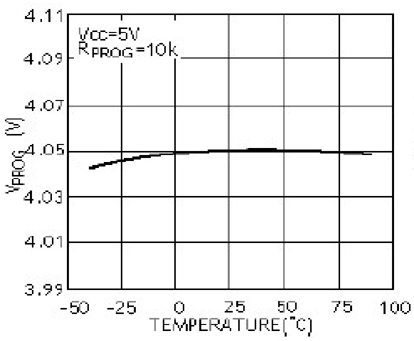
The relationship between charging current and supply voltage



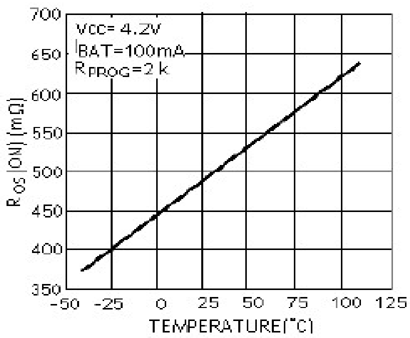
Relationship between charging current and ambient temperature



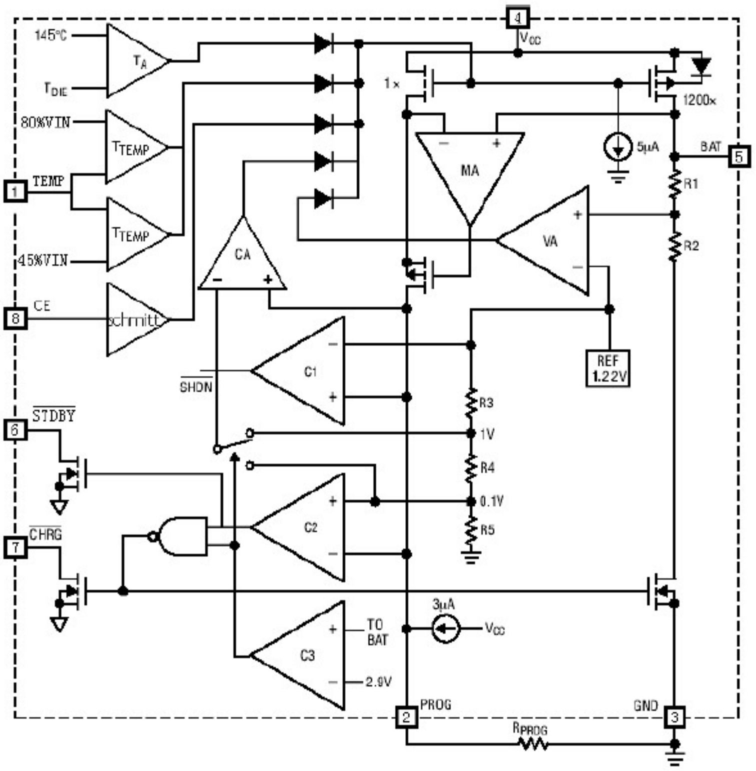
Recharge Voltage Threshold vs. Temperature



powerFET""On" Resistance vs. Temperature



9. Block diagram and working principle



-**Setting of charging current**

The charging current is taken from a connection inPROGset by a resistor between the pin and ground. The setting resistor and charging current are calculated using the following formula: Determine the resistance value of the resistor according to the required charging current

$$R_{PROG} = \frac{1200}{I_{BAT}} \quad （误差\pm10\%）$$

In the application, the appropriate size can be selected according to the needsR_{PROG}value, please refer to the following table:

R_{PROG}(KΩ)	I_{BAT}(mA)
4	300
3	400
2	580
1.5	780
1.2	1000

-**Charge terminated**

When the charging current drops to the set value after reaching the final float voltage1/10, the charge cycle is terminated. This condition is achieved by using an internal filtered comparator toPROGThe pin is detected by the temporary control. whenPROGpin voltage drops to100mVThe following time exceeds t_{TERM}(usually 1.8ms), charging is terminated. The charging current is latched off,4056Henters standby mode, at which point the input supply current drops to55UA. (Note:C/10termination is disabled in trickle charge and thermal limit modes).

-charge status indicator

4056HThere are two open-drain status indication outputs,CHRGandSTDBY. When the charger is charging,CHRGis pulled low, in other states,CHRGin a high impedance state. When the temperature of the battery is outside the normal temperature range,CHRGandSTDBYThe pins are all output in a high-impedance state. whenTEMPWhen the terminal is used in a typical connection method, when the battery is not connected to the charger, it indicates a fault state: both the red and green lights are not on

existTEMPterminationGNDWhen the battery temperature detection does not work, when the battery is not connected to the charger,CHRGThe output pulse signal indicates that no battery is installed. When the battery connectionBATThe external capacitance of the pin is10uFTimeCHRGFlashing frequency approx.1-4second

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

charging	red lightCHRG	green lightSTDBY
charging status	Bright	extinguish
full voltage	extinguish	Bright
Undervoltage, battery temperature is too high, too low and other fault conditions, or no battery intervention (TEMPuse)	extinguish	extinguish
BATtermination10uCapacitor, no battery (TEMP=GND)	Green light on, red light flashing T=1-4S	

-**thermal limitation**

If the chip temperature rises to about110℃ above the preset value, an internal thermal feedback loop will reduce the set charge current until150℃ above reduce the current to0. This feature prevents4056Hoverheating, and allows the user to increase the upper limit of the power handling capability of a given board without damage4056Hrisks of. The charging current can be set based on typical (rather than worst-case) ambient temperature, with the assurance that the charger will automatically reduce the current under worst-case conditions.

-**Battery temperature monitoring**

In order to prevent damage to the battery caused by high or low temperature,4056HA battery temperature monitoring circuit is integrated inside. Battery temperature monitoring is done by measuringTEMPpin voltage achieved,TEMPpin voltage is determined by the batteryNTCThermistor and a resistor divider network are implemented as shown in1 shown.

4056HWillTEMPThe voltage of the pin is the same as the two thresholds inside the chipV_{LOW}andV_{HIGH}Compare to confirm whether the temperature of the battery exceeds the normal range. exist4056Hinternal,V_{LOW}fixed in45%×Vcc,V_{HIGH}fixed in80%×Vcc. ifTEMPpin voltage$V_{TEMP}<V_{LOW}$or $V_{TEMP}>V_{HIGH}$, it means that the temperature of the battery is too high or too low, the charging process will be suspended; ifTEMPpin voltageV_{TEMP}existV_{LOW}andV_{HIGH}

In between, the charging cycle continues.

if theTEMPIf the pin is connected to ground, the battery temperature monitoring function will be disabled.

-SureR1andR2the value of

R1andR2The value of is determined according to the temperature monitoring range of the battery and the resistance value of the thermistor. Now an example is given as follows: Suppose the set battery temperature range isT_L~T_H,(in$T_L<T_H$); a negative temperature coefficient thermistor is used in the battery (NTC),$R_{TL}$for it

in temperature$T_L$resistance value when$R_{TH}$for its temperature$T_H$resistance value when$R_{TL}>R_{TH}$, then, at temperatureT_L, the first pinTEMPThe voltage at the terminal is:

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

in temperatureT_H, the first pinTEMPThe voltage at the terminal is:

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

Then, by$V_{TEMPL}=V_{HIGH}=k_2\times Vcc$ ($k_2=0.8$) $V_{TEMPH}=V_{LOW}=k_1\times Vcc$ ($k_1=0.45$) can be solved:

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

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

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

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

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

As can be seen from the above derivation, the temperature range to be set is related to the supply voltageVccis irrelevant, only withR1,R2,R_{TH},R_{TL}relating to; of which, R_{TH},R_{TL}It can be obtained by consulting the relevant battery manual or through experimental tests. In practical applications, if you only pay attention to the temperature characteristics of one end, such as overheating protection, thenR2can not be used, but only useR1That's it.R1The derivation is also simplified, and will not be repeated here.

-**undervoltage lockout**

An internal undervoltage lockout circuit monitors the input voltage andVccKeeps the charger in shutdown until it rises above the undervoltage lockout threshold. UVLOThe circuit will keep the charger in shutdown mode. ifUVLOComparator transitions, theVccrises higher than the battery voltage100mVThe charger will not exit shutdown mode before.

-Manual shutdown

at any point during the charge cycle by setting theCEterminal is low or removedR_{PROG}(So thatPROGpin floating) to put4056Hput in stop mode. This reduces the battery leakage current to2μAbelow, and the supply current drops to55μAthe following. resetCETerminating high or connecting a set resistor initiates a new charge cycle. if4056His in undervoltage lockout mode, theCHRGand the pin is in a high impedance state: orVcchigher thanBATInsufficient magnitude of pin voltage100mV, either imposed onVccInsufficient voltage on the pin.

-automatic restart

Once the charge cycle is terminated,4056Himmediately adopt a1.8msfilter time (RECHARGE t) of the comparator toBATThe voltage on the pin is continuously monitored. When the battery voltage drops to4.0V(approximately corresponding to the battery capacity of80%to90%), the charge cycle restarts. This ensures that the battery is maintained at (or close to) a fully charged state and eliminates the need for periodic charge cycle initiations. During the recharge cycle,CHRG The pin output goes into a strong pull-down state.

-thermal consideration

becauseESOP8The package size is small, therefore, a thermally well-designedPCBIt is important to layout the board to maximize the available charge current. for dissipationICThe heat dissipation path for the generated heat is from the die to the lead frame and through the bottom heat sink to PCBPlate copper surface.PCBThe copper surface of the board is the heat sink. The copper area where the heat sink is attached should be as wide as possible and extend out to the larger copper area to dissipate the heat to the surrounding environment. Vias to inner or back copper circuit layers are also useful in improving the overall thermal performance of the charger. when carried outPC Other heat sources on the board that are not related to the charger must also be considered when designing the board layout, as they will have an impact on the overall temperature rise and maximum charge current.

-Increase thermal regulation current

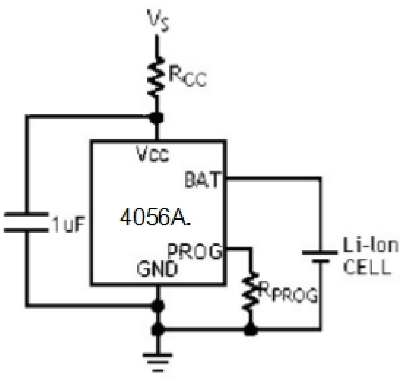
lower interiorMOSFETThe pressure drop across the two ends can be significantly reducedICpower consumption in . This has the effect of increasing the current delivered to the cell during thermal conditioning. One countermeasure is to dissipate some of the power through an external component such as a resistor or diode.

Example: Programmatically make a slave5VAC adapter to obtain working power4056Hto a3.75VThe voltage of the discharged Li-Ion battery is set to 1000mAfull-scale charge current. Assumptionθ_{JA}for125°C/W, then in25Under the ambient temperature condition of ℃, the charging current is approximately:

$$I_{BAT} = \frac{145°C - 25°C}{(5V - 3.75V) \bullet 125°C/W} = 768mA$$

by lowering one with5VThe voltage across the resistor in series with the AC adapter (Fig.3shown), which reduces the thermal power dissipation on the chip, thereby increasing the thermally regulated charge current:

$$I_{BAT} = \frac{145°C - 25°C}{(V_S - I_{BAT}R_{CC} - V_{BAT}) \bullet \theta_{JA}}$$



picture3: A circuit that maximizes the charge current in thermal regulation mode

Using the quadratic equation to find2

$$I_{BAT}=\frac{(V_S-V_{BAT})-\sqrt{(V_S-V_{BAT})^2-\frac{4R_{CC}(145°C-T_A)}{\theta_{JA}}}}{2R_{CC}}$$

PickR_{CC}=0.25Ω,V_S=5V,V_{BAT}=3.75V,T_A=25℃ and125°C/W$_{JA}$$q$, we can calculate the thermally adjusted charge current:I_{BAT} =948mA,The results show that the structure can output at higher ambient temperature800MAFull charge. While this application can deliver more energy to the battery and reduce charging time in thermal regulation mode, in voltage mode, ifV_{CC}becomes low enough that4056Hin a low dropout state, it actually has the potential to extend the charging time. picture4shows how this circuit works withR_{CC}increases, resulting in a voltage drop. When used to keep component size small and avoid pressure dropR_{CC}This technique works best when the value is minimized. Remember to choose a resistor with sufficient power handling capability.

-VCCBypass capacitor

Input bypassing can use many types of capacitors. However, care must be taken when using multilayer ceramic capacitors. Since some types of ceramic capacitors have self-resonance and highQTherefore, high voltage transients may be generated under certain start-up conditions (such as connecting the charger input to a working power supply). add one withX5RCeramic capacitors connected in series1.5ΩResistors will minimize startup voltage transients.

4056H**Precautions for use**

one,4056HPrecautions for use:

1,4056HuseESOP8-PPpackage, the bottom heat sink should be connected to thePCBThe board is well soldered, and the bottom heat dissipation area needs to add through holes and have a large surface

The heat dissipation of copper foil is better. multilayerPCBAdding sufficient vias has a good effect on heat dissipation. Poor heat dissipation may cause the charging current to be reduced by temperature protection. existESOP8

Appropriate via holes are added to the heat dissipation part on the back, which is also convenient for manual soldering (you can fill in solder from the back via holes to reliably solder the heat dissipation surface).

2,4056Happlied in high current charging (1000mAabove), in order to shorten the charging time, it is necessary to increase the heat dissipation resistance,VCCThe input is connected in series with a power

resistance, resistance range0.2~0.5Ω. The customer selects the appropriate resistor size according to the usage.

3,4056Hin applicationBATend10ucapacitor location to be close to the chipBATThe end is the best, not too far.

4,4056Htesting,BATThe terminal should be directly connected to the battery, and the ammeter cannot be connected in series. The ammeter can be connected toVccend.

5. In order to ensure reliable use in various situations and prevent chip damage caused by spikes and glitches, it is recommended to useBATterminal and power input terminal and then connect one each

0.1uceramic capacitors, and routed very close to4056Hchip. 6,VCCThe

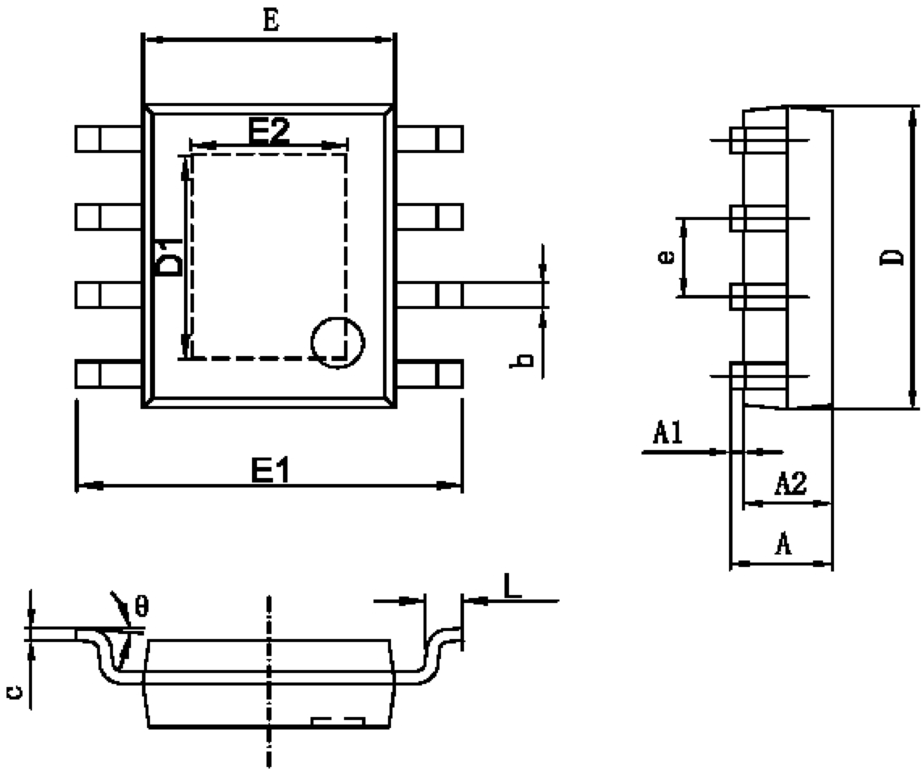
power input can also be madeRCFilter circuit to increase chip reliability.

7. For the scheme with a motor in the back-end load, the noise cancellation filter processing should be strengthened for the motor drive circuit to filter out the high-voltage spike noise generated by the motor operation.

To ensure the stability of the charging chip.

10. Package description

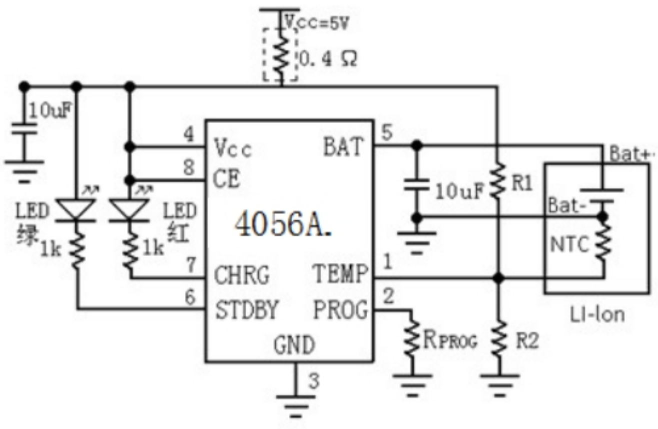
8pinESOP-8package (unitmm)



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°

8Pin Package (Unitmm)

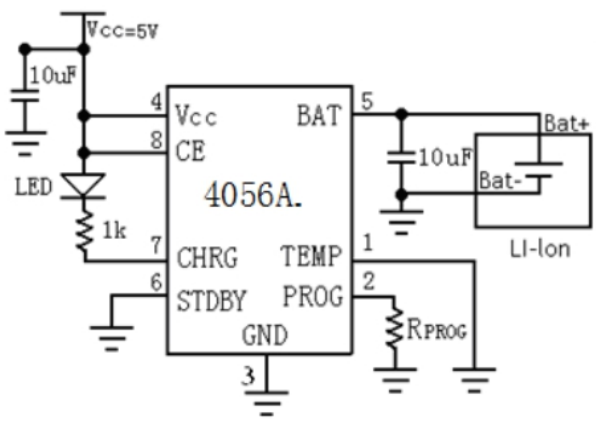
11. Typical applications

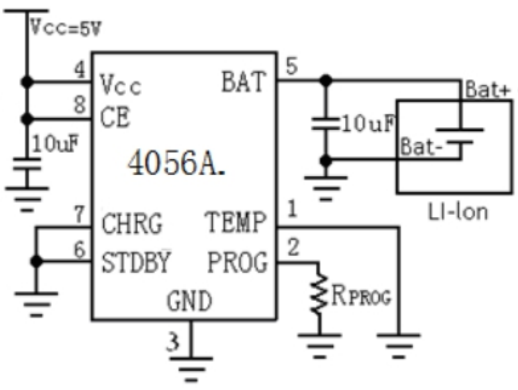


Suitable for battery temperature detection function, abnormal battery temperature indication

and application of charge status indication and adding thermal dissipation power resistors

TEMPpin voltage is less than2.2VWhen the output voltage is turned off, the charging current is0;TEMPpin voltage greater than4.0When the charging current is gradually decrease.



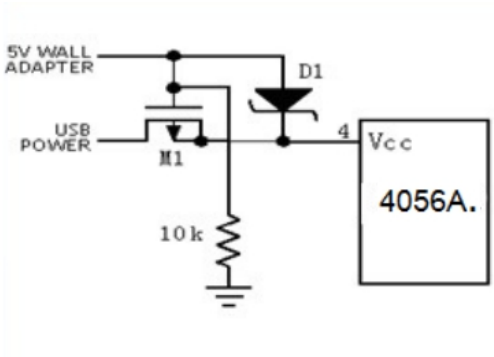


Suitable for charging status indication, not required

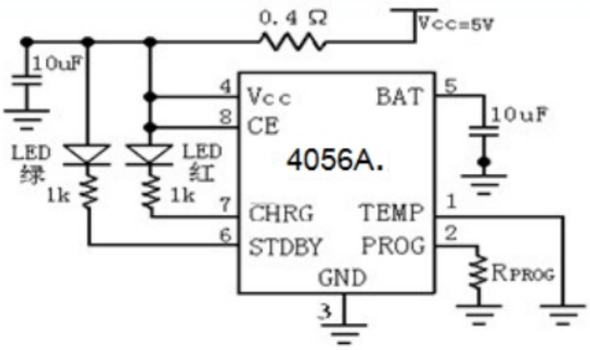
Application of battery temperature monitoring function

Suitable for neither charging status indication nor

Application of battery temperature monitoring function



Suitable for simultaneous applicationUSBInterface and wall adapter charging



red for charging statusledIndication, charging end status

with greenledindication, increase the heat dissipation power resistor