LN2051

1A is compatible with the USB interface, linear battery management chip

■ General Description

The LN2051 is a constant- current / constant- voltage charger circuit for single cell lithium-ion batteries. The device includes an internal power transistor, does not need external current sense resistor and blocking diode in applications. LN2051 requires minimal external components, and meet the USB bus specification, is very suitable for portable applications in the field.

Thermal modulation circuit can control the chip temperature in a safe range when the device power dissipation be relatively large or the ambient temperature be higher. Within a fixed constant charge voltage 4.2V, can also be adjusted by an external resistor. Charge current set by an external resistor.

When the input voltage (AC adapter or USB power supply) power is lost, LN2051 automatically enters a low power sleep mode, then the battery current consumption is less than 3μA. Built-in protection circuits against irrigation, when the battery voltage is higher than the input voltage, automatically turn off built-in power MOSFET. Other features include low input voltage latch, automatic recharge, the battery temperature monitoring and charge status / charge status indication functions.LN2051 uses thermally enhanced 8-pin small outline package SOP-8 or MSOP-8.

■ Applications

- Mobile phones
- Digital cameras
- MP4 player
- Bluetooth applications
- Electronic dictionary
- Portable devices
- All kinds of charger

■ Features

- Programmable charge current up to 1A
- No MOSFET, sense resistor or blocking diode required
- Complete linear charger in small package for single cell lithium-ion batteries

- Constant-Current/Constant-Voltage operation with thermal regulation to maximize charge rate without risk of overheating
- Charges single cell li-Ion batteries directly from USB port
- Preset 4.2V charge voltage with ±1% accuracy, also can be adjusted by FB
- Monitor output charge current
- Automatic recharge
- Charge status output pin
- 1/10 charge current termination
- 25μA supply current in shutdown
- 2.9V trickle charge threshold
- Soft-Start limits inrush current
- output with protection against anti-irrigation
- Available in SOP-8 or MSOP-8 Package

■ Package

- SOP-8/PP

SOP-8
(Top View)
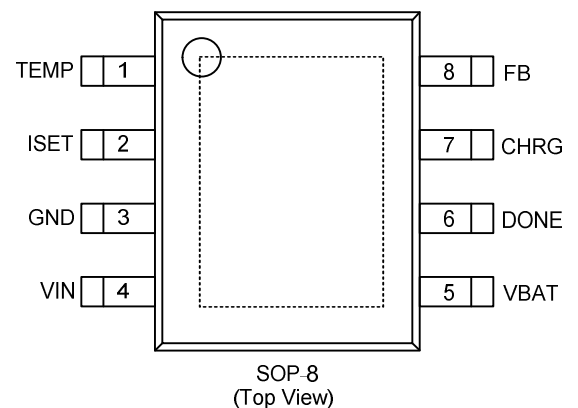
- MSOP-8/PP

MSOP-8
(Top View)
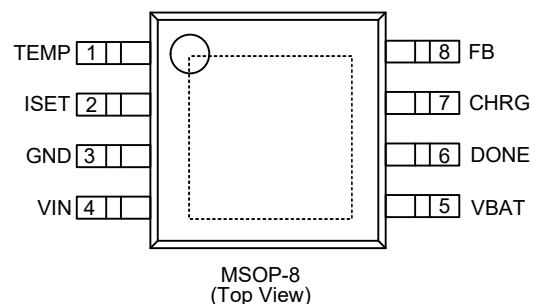
■ Ordering Information

LN2051①②③④⑤－⑥

Designator	Description	Symbol	Description
①	Type	X	No trickle charge
		Y	Have trickle charge
②	The first part of regulator Output Voltage	0	4.0
		1	4.1
		2	4.2
③	The second part of regulator Output Voltage	A	②00
		B	②25
		C	②50
		D	②75
④	Packaging Types	S	SOP-8/PP
		Q	MSOP-8/PP
⑤	Device Orientation	R	positive
		L	negative
⑥	Component Material	G	Halogen-free

■ Pin Function

● **TEMP (Pin 1):** The TEMP pin to the battery of the NTC sensor output. If the TEMP pin voltage is less than the input voltage of 30% or greater than 60% of the input voltage means the battery temperature is too low or too high, then the charge will be suspended. If the TEMP input voltage between 30% and 60%, then the battery fault condition will be cleared, the charge will continue.

● **ISET (Pin 2):** Charge current programming, charge current monitoring and close pin. Charge current is controlled by a resistor of precision of 1%to the ground. In the constant charge current state, this port provides 1V voltage. In all conditions, this port charge current can be calculated using the following formula:

$$IBAT = (VISET/RISET) \times 1250$$

I_{SET} port can also be used to turn off the charger. Resistance to side with the separation of programming can pull the 3μA current source to increase I_{SET} port voltage. When the suspension reached the limit voltage 1.21V, the device enters stop state, after charging the input current drop to 25μA. This port pinch-off voltage is about 2.4V. If supply this port voltage more than pinch-off voltage, the current will be 1.5 mA. Through combinating I_{SET} pin to the ground, the charger will back to normal.

● **GND (Pin 3):** Ground terminal

● **VIN (Pin 4):** Supply positive input voltage. Power supply for the charger. V_{CC} can be 4.25V to 6.5V and must have at least 1F bypass capacitor. If the BAT pin voltage of V_{CC} down to within 30 mV, LN2052 into the suspension state, and make BAT Current less than 2A.

● **BAT (Pin 5):** Make the battery's positive terminal connected to this pin. When the power supply voltage lower than the threshold latch voltage or sleep mode voltage, BAT pin current is less than 2μA. BAT pin provide the battery charge current and constant voltage charging voltage.

● **DONE (Pin 6):** When charging end, DONE pin is pulled low by internal switch represents that charge has ended;

otherwise DONE pin is high impedance state.

- **CHRG (Pin 7):** When the charger to the battery charging, CHRG pin is pulled low by the internal switch,represents charging being; otherwise CHRG pin is in high impedance state.

- **FB (Pin 8):** This pin can test Kelvin battery voltage, and thus precisely modulated constant voltage battery charging voltage, avoiding the positive from the battery to the BAT pin LN2051 or contact resistance between the resistance wire and other parasitic resistance of the charge. If the FB pin and the BAT pin is an indirect one resistor, users can adjust the constant charging voltage

■ Marking Rule

- **SOP-8/PP、MSOP-8/PP**

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LN2051
① ② ③  YYWW


○
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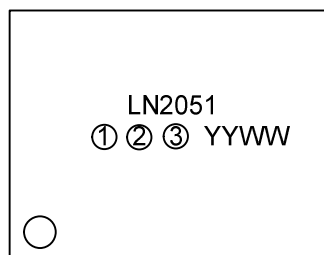
① **Represents the function type**

Symbol	Description
X	No trickle charge function
Y	Have trickle charge function

②③ **Represents the output voltage**

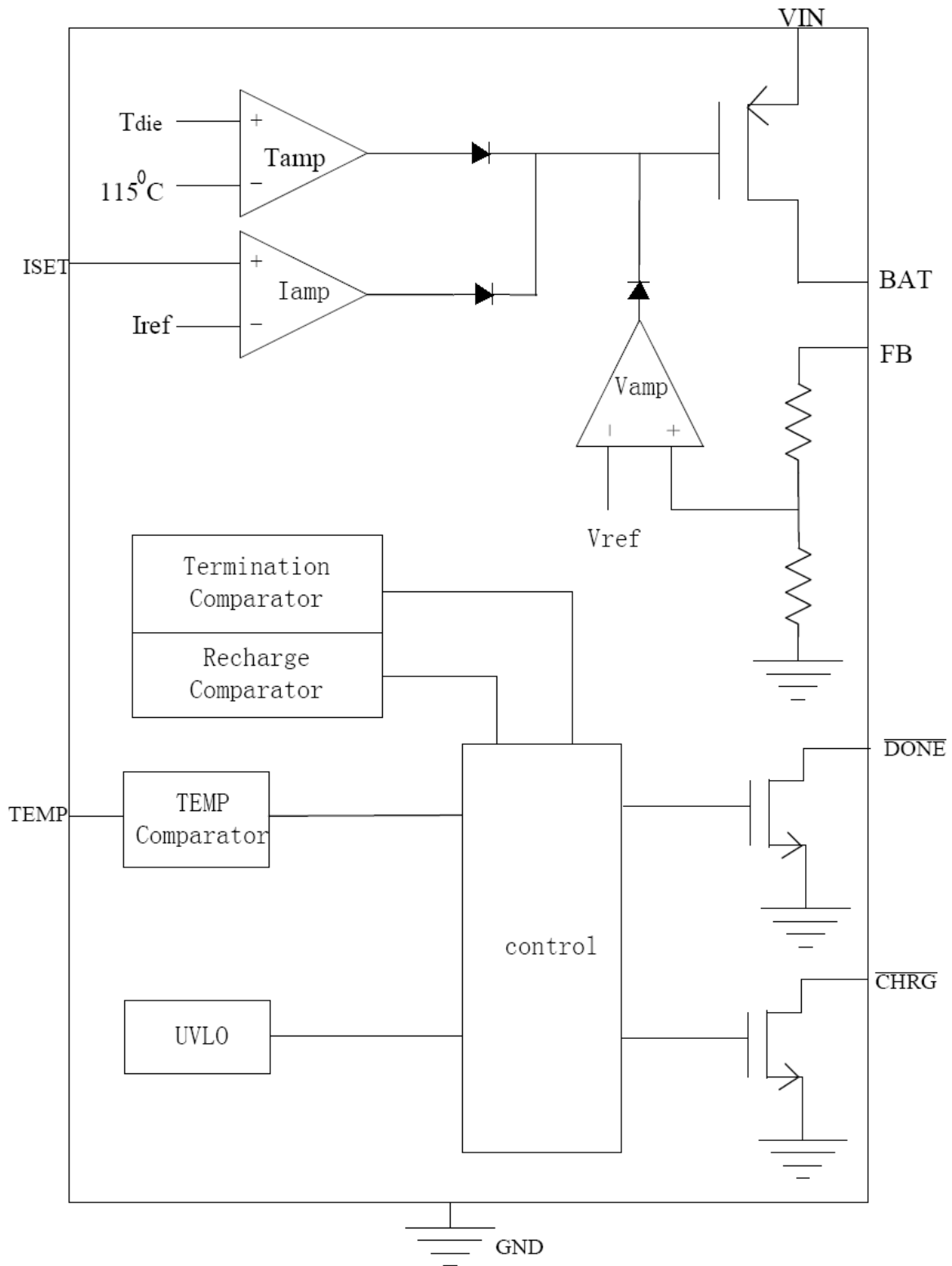| Symbol	Voltage		Symbol	Voltage		Symbol	Voltage
0A	4.0		1A	4.1		2A	4.2
0B	4.025		1B	4.125		2B	4.225
0C	4.050		1C	4.150		2C	4.250
0D	4.075		1D	4.175		2D	4.275

■ Block Diagram

Figure 1.

■ Absolute Maximum Ratings

Parameter	Symbol	Maximum Rating	Unit
Input Supply Voltage	V_{cc}	$V_{SS}-0.3\sim V_{SS}+7$	V
ISET pin Voltage	Vprog	$V_{SS}-0.3\sim V_{cc}+0.3$	
BAT pin Voltage	Vbat	$V_{ss}-0.3\sim 6$	
DONE pin Voltage	Vdone	$V_{SS}-0.3\sim V_{SS}+7$	
CHAG pin Voltage	Vchrg	$V_{SS}-0.3\sim V_{SS}+7$	
BAT pin Current	Ibat	1500	mA
ISET pin Current	Iprog	1500	uA
Operating Ambient Temperature	Topa	$-40\sim+85$	°C
Storage Temperature	Tstr	$-65\sim+125$	

Caution: The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.

■ Typical Application Circuit

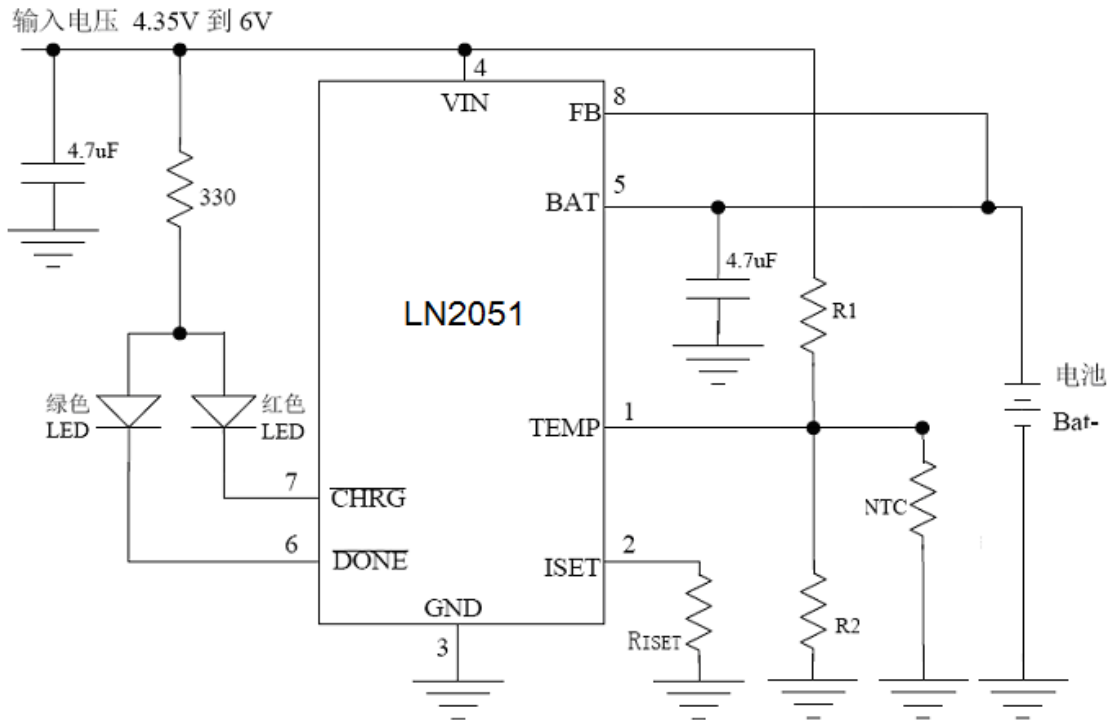● Constant- current / constant- voltage 4.2V Charging Application

Figure 2.

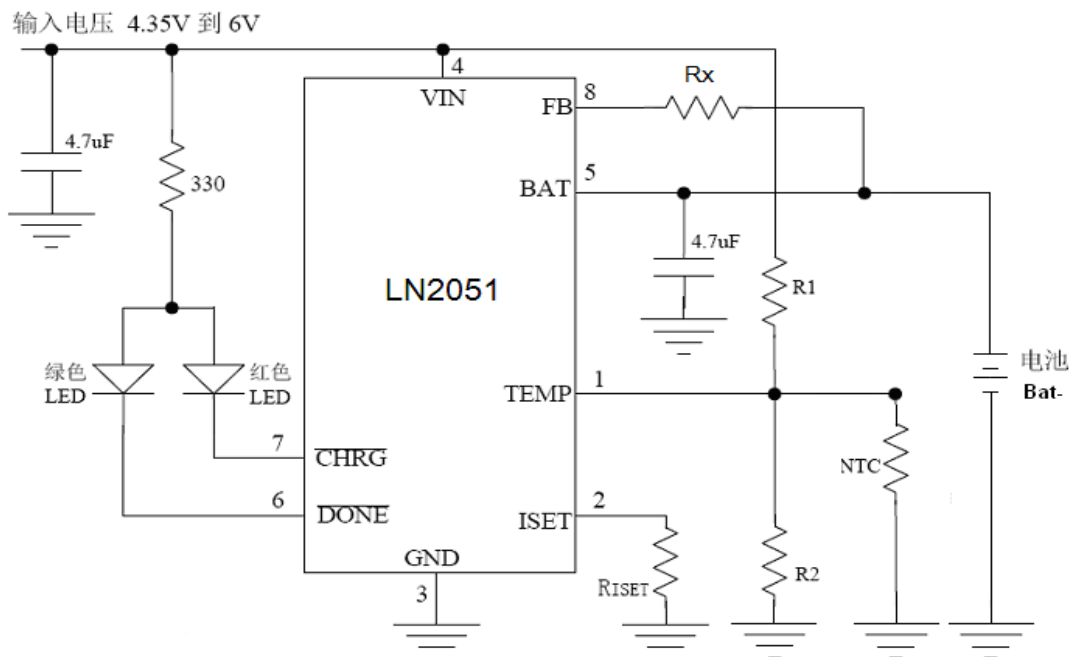● Using an external resistor to regulate the Constant Flow Constant Pressure Applications

Figure 3.

■ Electrical Characteristics

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input supply voltage	Vcc		4.25		6.5	V
Input supply current	Icc	Charge mode,Riset=10K		200	2000	μA
		Standby mode		200	500	μA
		Shutdown mode(Riset not connected,Vcc<Vbat or Vcc<Vuv)		25	50	μA
Regulated Output Voltage	Vfloat	0℃≤TA≤85℃,IBAT= 40mA	4.16	4.2	4.25	V
BAT pin Current	Ibat	Riset=10k,Current mode	115	125	135	mA
		Riset=1k,Current mode	1150	1250	1350	mA
		Riset=830,Current mode	1400	1500	1600	mA
		Standby mode,Vbat=4.2V	0	-2.5	-6	μA
		Shutdown mode		±1	±2	μA
		Sleep mode,Vcc=0V		±1	±2	μA
Trickle charge current	Itrikl	Vbat<Vtrikl,Rprog=2k	40	65	90	mA
Trickle charge Threshold Voltage	Vtrikl	Riset=10K，Vbat Rising	2.8	2.9	3.0	V
Trickle voltage hysteresis voltage	Vtrhys	Riset=10k	60	80	110	mV
Vcc Undervoltage lockout Threshold	Vuv	From Vcc low to high	3.7	3.8	3.93	V
Vcc undervoltage lockout hysteresis	Vuvhys		150	200	300	mV
Manual shutdown threshold voltage	Vmsd	Iset pin rising	1.15	1.21	1.30	V
		Iset pin falling	0.9	1.0	1.1	V
Vcc-Vbat Lockout Threshold voltage	Vasd	Vcc from low to high	70	100	140	mV
		Vcc from high to low	5	30	50	mV
C/10 Termination Current Threshold	Iterm	Riset=10k	10	13	16	mA
		Riset=2k	40	65	90	mA
PROG pin Voltage	Vprog	Riset=10k, Current mode	0.93	1.0	1.07	V
CHRG pin Output low voltage	Vdone	Idone=5mA		0.35	0.6	μA
CHRG pin Output low voltage	Vchrg	Ichrg=5mA		0.35	0.6	V
Recharge Battery threshold Voltage	ΔVrecg	VFLOAT - VRECHRG		150	200	mV

■ Application Information

● **Kelvin battery voltage detection**

LN2051 Kelvin detect a battery voltage input (FB), this pin through the chip internal precision resistor divider network connected to the constant voltage error amplifier. FB pin can be connected directly to the battery cathode, it can effectively prevent the parasitic resistance(including lead resistance, contact resistance, etc.) between the battery and the 5th pin of LN2051 . The parasitic resistance will make the charger early enters the constant state and extend the charging time, even charge the battery discontent, by using Kelvin battery voltage detection can solve these problems. If the Kelvin detect input pin (FB) not connect, then the LN2051 has been in a pre-charge state, charging current is 1 / 10 of the set constant charge current.

● **Adjust the constant charging voltage**

If connect a resistor between the LN2051 battery voltage Kelvin test input pin (FB) and the positive battery , it can increase the battery charging voltage, as shown in Figure 3, then the positive battery voltage Vbat is:

$$Vbat（V） = 4.2＋4.03×10^{-6}×Rx（Ω）$$

When using an external resistor to adjust the charging voltage constant, due to internal and external temperature of chip and chip production inconsistent with the process variation and other factors, may cause the accuracy of the output voltage variation and temperature coefficient.

● **Application of USB and AC adapter while charging at the same time**

LN2051 can not only use USB interface to charge the battery, users can also use a wall adapter to charge the battery. Figure 4 shows a the same time using the USB interface and the AC adapter to charge the battery through the LN2051 .when the two co-exist, the AC adapter has priority. M1 is the P-channel MOSFET, M1 is used to prevent current from a wall adapter into the USB interface, USB interface, Schottky diode D1 prevents the consumption of energy through the 1K resistor.
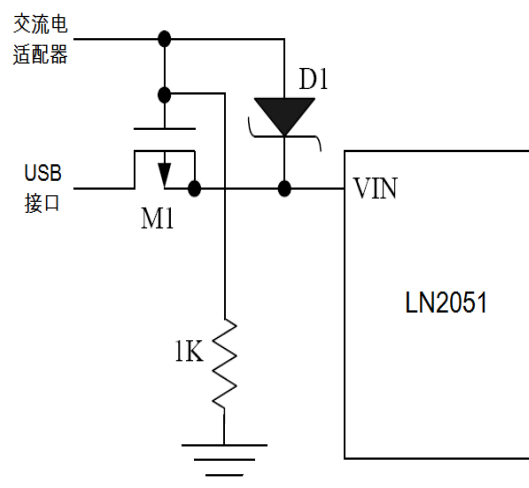

Figure 4. While using the AC adapter and USB interfaces

● **Set the charge current**

In constant-current mode, formula for calculating charge current: ICH = 1250V / RISET
ICH represents the charge current, units is ampere, RISET represents ISET pin to ground resistance in ohms.For example, if you need 500mA charge current, according to the following formula: RISET = 1250V/0.5A = 2.5kΩ

In order to ensure good stability and temperature characteristics, RISET recommend the use of 1% precision metal film resistors. By measuring the ISET pin voltage can be detected charge current. Charge current can be calculated using the following formula: ICH = (VISET / RISET) × 1250

● **Battery temperature monitoring**

In order to prevent the battery temperature is too high or too low on the battery damage, LN2051 internal battery temperature monitoring of integrated circuits. Battery temperature monitoring is by measuring the TEMP pin voltage to achieve, TEMP pin voltage is within the battery NTC thermistor and a resistor divider network, and illustrated in Figure 2.

LN2051 the TEMP pin voltage with the chip and the two thresholds VLOW VHIGH compared to confirm whether the battery temperature exceeds the normal range. In the LN2051, VLOW were fixed in 30% × VIN, VHIGH were fixed in 60% × VIN. If the TEMP pin voltage VTEMP <VLOW or VTEMP> VHIGH, the battery temperature is too high or too low, charging will be suspended; If the TEMP pin voltage VTEMP VLOW and VHIGH in between, the charge cycle will continue.

● **Enable design**

By controlling whether the ISET pin resistor connected, users can reach close LN2051 function. Figure 5:
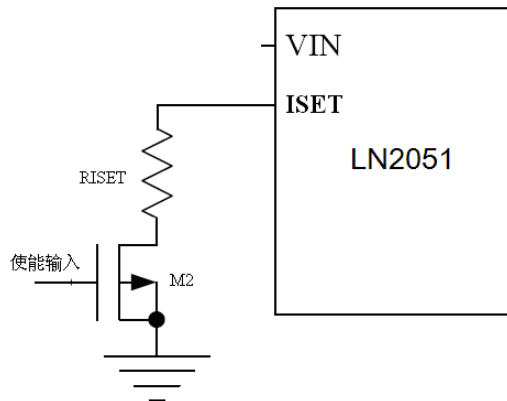

Figure 5.   LN2051 Enable Design

● **Determine the value of R1, R2**

The value of R1 and R2 according to battery temperature monitoring range and the thermistor resistance values to determine, are described as follows: assume that the temperature range of the battery set TL ~ TH, (TL <TH); batteries used in negative temperature coefficient thermistor (NTC), RTL TL when its temperature resistance, RTH its resistance when the temperature TH, then the RTL> RTH, then the temperature TL, the first pin TEMP-side voltage is:

$$V_{TEMPL} = \frac{R_2 / / R_{TL}}{R_1 + R_2 / / R_{TL}} \times Vin$$

When temperature reach TH, the first side of the TEMP pin voltage is: $V_{TEMPH} = \frac{R_2 / / R_{TH}}{R_1 + R_2 / / R_{TH}} \times Vin$

then，according to $V_{TEMPL} = V_{HIGH} = K2 \times V_{IN}(K2 = 0.6)$

$$V_{TEMPH} = V_{LOW} = K1 \times V_{IN}(K1 = 0.3)$$

Can solve for： $R1 = \frac{R_{TL}R_{TH}(K2 - K1)}{(R_{TL} - R_{TH})K1K2}$

$$R2 = \frac{R_{TL}R_{TH}(K2 - K1)}{R_{TL}(K1 - K1K2) - R_{TH}(K2 - K1K2)}$$

Similarly, if the battery is the positive temperature coefficient of internal (PTC) thermistor, the RTH> RTL, we can calculate:

$$R1 = \frac{R_{TL}R_{TH}(K2-K1)}{(R_{TH}-R_{TL})K1K2}$$

$$R2 = \frac{R_{TL}R_{TH}(K2-K1)}{R_{TH}(K1-K1K2)-R_{TL}(K2-K1K2)}$$

From the above derivation can be seen to be setting the temperature range and supply voltage VIN is irrelevant, only with R1, R2, RTH, RTL; one, RTH, RTL can access the relevant manuals or through experimental test battery be.

In practice, if only one side of the temperature characteristics of concern, such as over-temperature protection, then R2 can not, and can only R1. R1 derivation becomes very simple, not discussed here.

● **Open-drain output status indication**

LN2051has two open-drain status indication sides, CHAG and DONE, the two status indicator LEDs client can drive or microcontroller port. CHAG used to indicate charging status, charging time, CHAG is low; DONE to indicate the charging end of the state, when the charging end, DONE is low. When the battery temperature is outside the normal temperature range more than 0.15 seconds, CHAG and the DONE pin is high impedance output state.

When the battery charger not received, the charger will quickly charge the output capacitor to the constant voltage value, as the battery voltage detection Kelvin FB pin input leakage current, FB pin and the BAT pin voltage will slowly down to recharge threshold, so the FB pin and the BAT pin voltage is 150mv to form a ripple waveform, while CHAG output pulse signal that there is no battery installed. When the battery BAT pin external connectors for the 4.7uF capacitor, the pulse period of about 2Hz. The following table lists CHAG and the DONE pin status in each case:

State	Charge	Full	Without Battery	Error
CHAG	Always bright	Always off	Flashing	Always off
DONE	Always off	Always bright	Always bright	Always off

Note: 1. CHAG flicker frequency with external capacitor when not connect battery, generally recommended 4.7uF.The greater the capacitance ,the smaller frequency flicker.

2. The error situation: Beyond the operating temperature range (temperature too high or too low), Iset side vacant, Vin <Vbat, Vin <3.8V and so on.

■ Package Information

- **MSOP-8/PP**
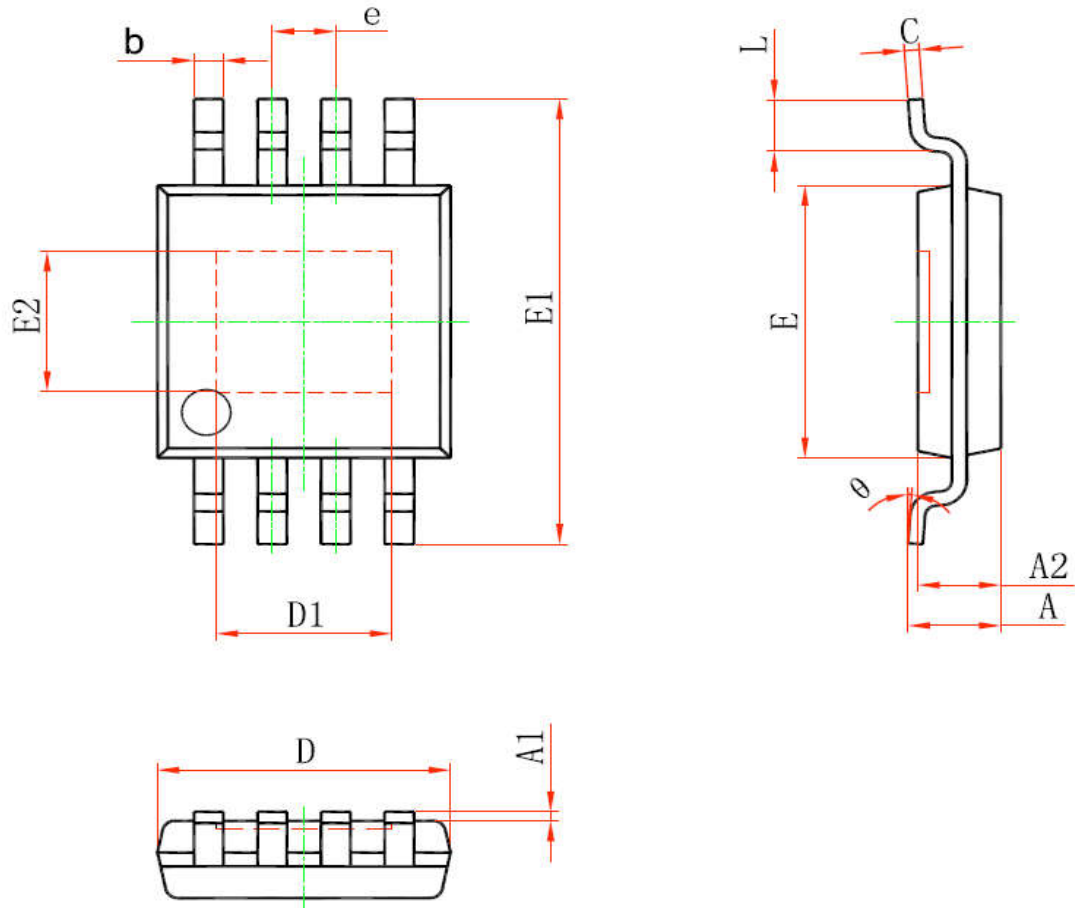
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
D1	1.700	1.900	0.067	0.075
e	0.65 （BSC)		0.026(BSC)	
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
E2	1.450	1.650	0.057	0.065
L	0.400	0.800	0.016	0.031
θ	0°	6°	0°	6°

- **SOP-8/PP**
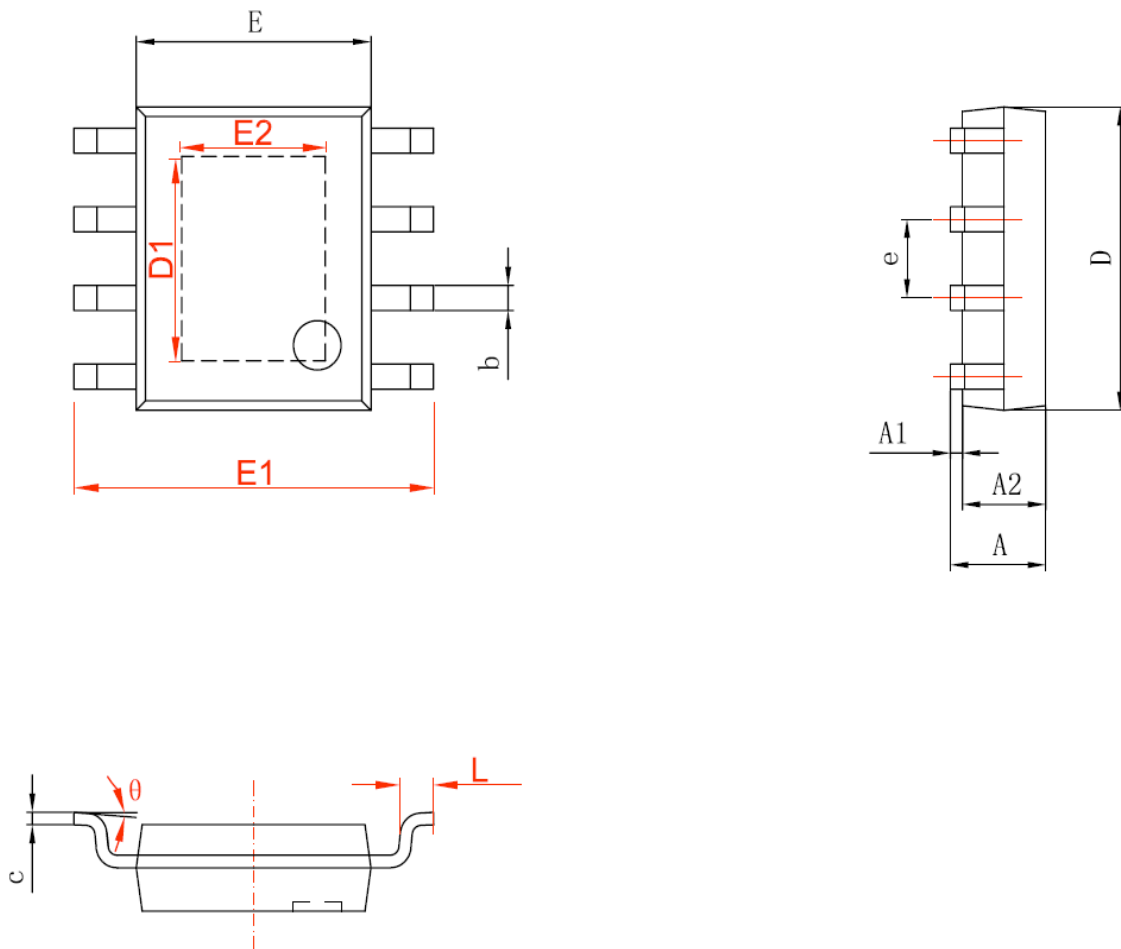
字符	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.150	0.002	0.006
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.200
D1	3.202	3.402	0.126	0.134
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	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°