

# Synchronous Switch Buck Charger for Single-cell Li Battery

## 1 Features

- **Synchronous switch-mode buck charger**
  - ✧ Built-in power MOS, maximum 2.4A switching charging, efficiency 92%
  - ✧ Standard 4.20V, other voltages need to be customized, support lithium iron phosphate battery, full voltage customization range 3.5V~4.4V
  - ✧ Charging current ISET pin can be set
- **Support NTC protection function**
- **Support 2-way LED lights**
  - ✧ LED1 supports constant current output function (no string current limit resistor required)
- **Low standby power consumption**
  - ✧ BAT power consumption is less than 2uA at VIN=0
- **Multiple protection and high reliability**
  - ✧ Input over-voltage, under-voltage and output over-charge protection
  - ✧ NTC monitoring battery temperature, 5-stage charging (Compatible with JEITA standard)
  - ✧ Chip over-temperature protection
  - ✧ ESD 4KV

## 2 Typical Applications

- **Single lithium battery charging**

## 3 Description

IP2332 is a 5V VIN that supports single lithium battery synchronous buck charge management chip.

The IP2332 integrated power MOS and synchronous switching architecture enable it to require only a few peripheral components for the application, and effectively reduce the size of the overall solution and reduce the BOM cost.

IP2332 buck switching charging converter works at 500KHz, the maximum charging current is 2.4A, 5V input, 3.7V/2A conversion efficiency is 92%; The charging current can be set by an external resistor.

IP2332 input voltage is 5V and the input can intelligently regulate the charging current to prevent adapter failure.

IP2332 can support 2-channel LED light display; LED1 supports constant current output function (no string current limiting resistor required), and LED1 customizes breathing lamp function.

IP2332 supports NTC function, supports 5-segment NTC charging standard, NTC low or high temperature to stop charging, medium-low or medium-high temperature can reduce the charging current or reduce the full voltage.

IP2332 is packaged in ESOP8.

## 4 Simplify the application schematic

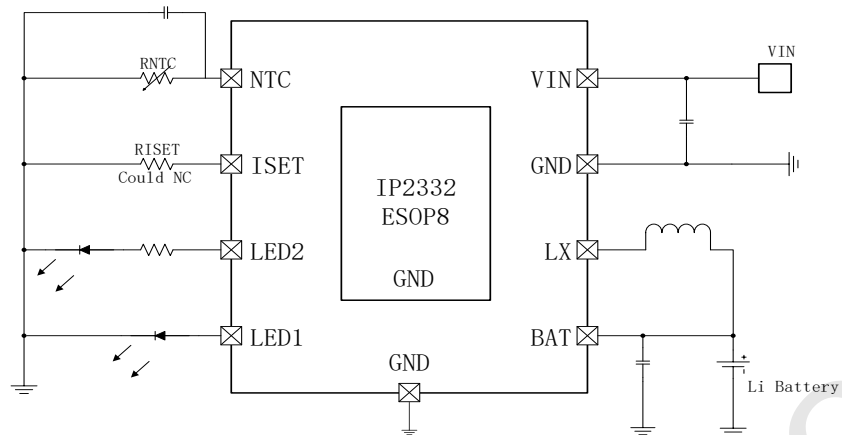


Figure 1 Simplify the application schematic

## Directory

1 Features.....	1
2 Typical Applications .....	1
3 Description.....	1
4 Simplify the application schematic.....	2
5 Modify records .....	4
6 PIN Description .....	5
7 Limit parameters.....	6
8 Recommended Operating Conditions.....	6
9 Electrical Characteristics .....	6
10 Function Description .....	8
10.1 Functional Block Diagram.....	8
10.2 Charging efficiency.....	8
10.3 Charge Process.....	11
10.4 Charging protection .....	11
10.5 Charge current setting.....	13
10.6 NTC .....	14
10.7 Charging LED indication.....	16
11 Typical Application Schematic .....	17
12 BOM .....	17
13 Silkscreen.....	19
14 Package.....	20
15 IMPORTANT NOTICE.....	21

## 5 Modify records

NOTE: The page numbers of the previous version may differ from the page numbers of the current version.

release version V1.00 (2023.11)	Page
• Initial release version.....	1
updated version 1.01 (2024.4)	Page
• Added the relationship between NTC voltage and NTC resistance.....	15
updated version 1.02 (2024.6)	Page
• Modify the charging lamp display when the battery is not connected.....	16
updated version 1.03 (2024.8)	Page
• Modify Silkscreen.....	19

## 6 PIN Description

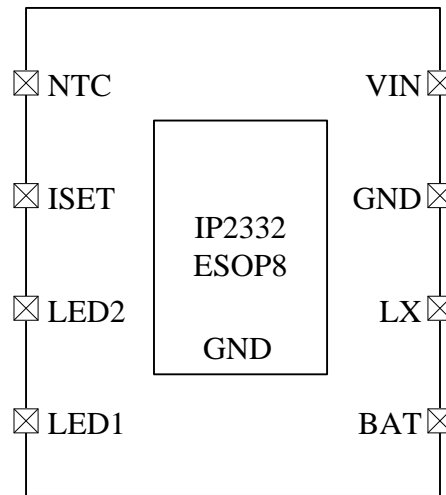


Figure 2 Pin of IP2332

Pin Name	Pin Num	Pin Description
NTC	1	The battery temperature detection pin is externally connected to the negative temperature coefficient resistor (NTC) to detect the battery temperature
ISET	2	Charge current setting pin
LED2	3	LED2 output pin (common IO output)
LED1	4	LED1 output pin (support constant current output, breathing light)
BAT	5	BAT pin, connect to the positive terminal of the battery
LX	6	DCDC switch node
GND	7	Ground
VIN	8	5V DC input pin
GND	EPAD	Ground

## 7 Limit parameters

Parameters	Symbol	Value	Unit
Pin input voltage range	$V_{MAX}$	-0.3 ~ 7.5	V
Operating ambient temperature range	$T_A$	0 ~ 70	°C
Junction Temperature Range	$T_J$	-40 ~ 150	°C
Storage Temperature Range	$T_{stg}$	-65 ~ 150	°C
Reflow temperature	$T_{RFL}$	260	°C
Human Body Model (HBM)	ESD	4	KV

\*Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to Absolute Maximum Rated conditions for extended periods may affect device reliability.

## 8 Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input Voltage	$V_{IN}$	4.5	--	6	V
Charge Current	$I_{BAT}$		--	2.4	A

\*Devices' performance cannot be guaranteed when working beyond those Recommended Operating Conditions.

## 9 Electrical Characteristics

Unless otherwise specified,  $T_A=25^{\circ}\text{C}$ ,  $L=2.2\mu\text{H}$ ,  $V_{IN}=5\text{V}$ ,  $V_{OUT}=3.7\text{V}$

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
<b>Charging System</b>						
Input Voltage	$V_{IN}$		4.5	5	6	V
Input under-voltage threshold	$V_{IN-UV}$		4.2	4.3	4.4	V
Input over-voltage threshold	$V_{IN-OV}$		5.8	6	6.2	V
Input overvoltage protection hysteresis				200		mV
Input Current	$I_{VIN}$	$V_{IN}=5\text{V}$ , $V_{BAT}=NC$ , NO LED		5	10	mA
Standby Current	$I_{standby-BAT}$	$V_{IN}=0$ , $V_{BAT}=3.7\text{V}$		1	2	uA
Charge Current	$I_{CC}$	$R_{ISET}=1.4\text{K}$		2.4		A
		$R_{ISET}=2.4\text{K}$		1.5		A
		$R_{ISET}=4.3\text{K}$		1		A

		$R_{ISET} \geq 120K$ , NC	1.8	2	2.2	A
Charge Target Voltage	$V_{CV}$	VIN=5V	4.16	4.2	4.24	V
Full charge stop detection voltage	$V_{SV}$			4.15		V
Charging voltage after full charge	$V_{RC}$			4.1		V
Trickle over constant current voltage	$V_{TK}$	VIN=5V	2.9	3	3.1	V
Trickle Charge Current	$I_{TK}$	VIN=5V, VBAT<3V,RISET=NC		$1/5 I_{CC}$		mA
Charge Cut-off Current	$I_{STOP}$	$I_{CC}=2A$		200		mA
<b>Control System</b>						
LED drive Current	$I_{Led}$	VIN=5V			5	mA
Thermal shutdown temperature	$T_{OTP}$	Rising Threshold	130	140	150	°C
Thermal shutdown hysteresis	$\Delta T_{OTP}$		30	40	50	°C

## 10 Function Description

### 10.1 Functional Block Diagram

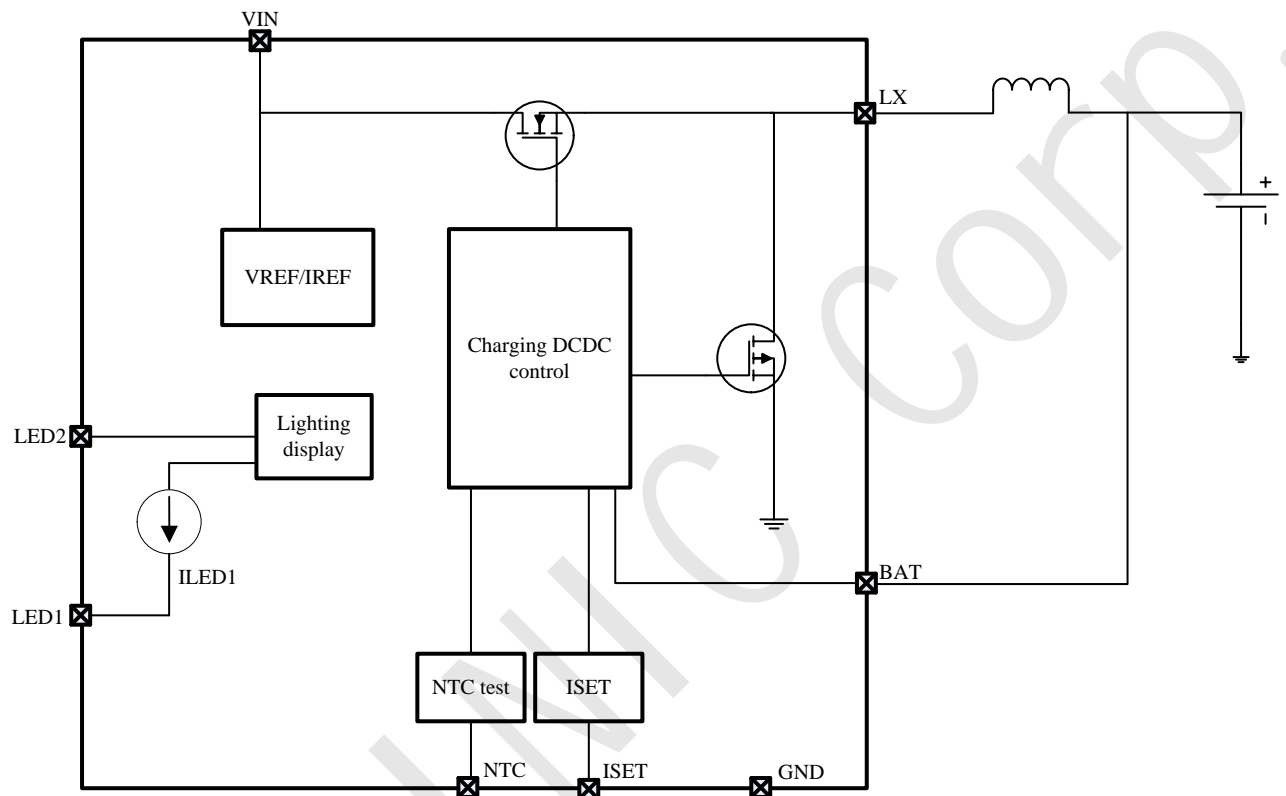


Figure 3 IP2332 Functional Block Diagram

### 10.2 Charging efficiency

IP2332 integrates a synchronous buck charge controller, integrated power MOS, switching frequency 500KHz, input 5V buck to charge the lithium battery. 5V input, 3.7V/2A output with 92% efficiency..



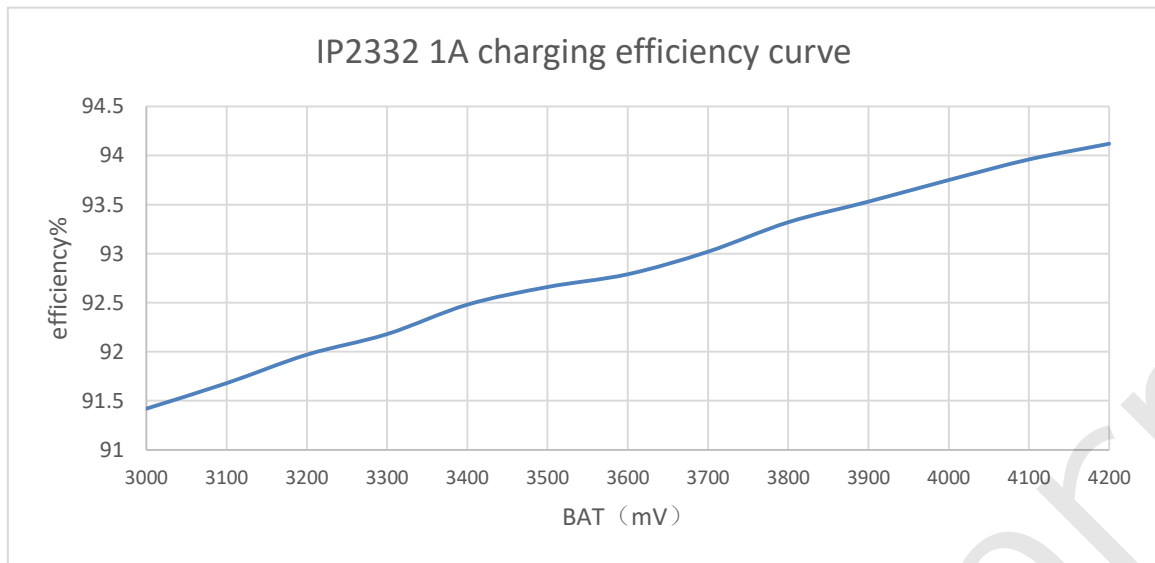


Figure 4 IP2332 1A charging efficiency curve

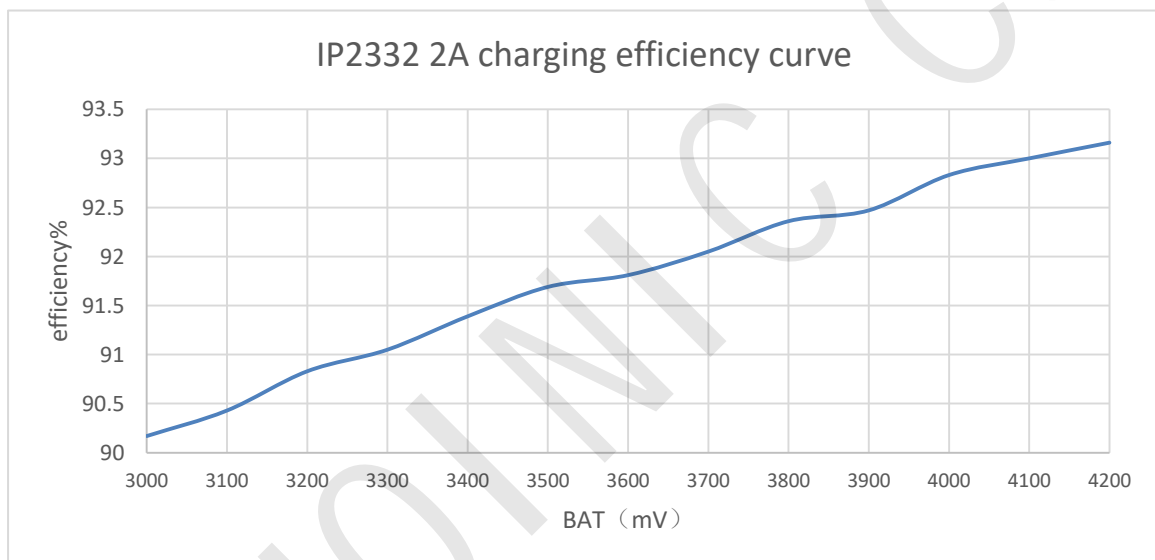


Figure 5 IP2332 2A charging efficiency curve

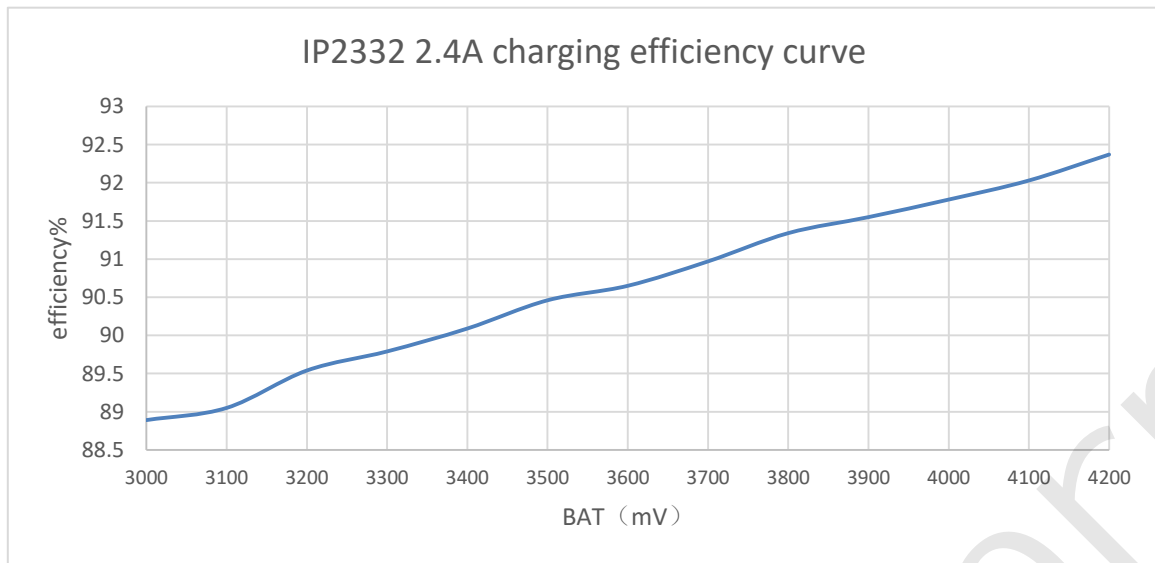


Figure 6 IP2332 2.4A charging efficiency curve

## 10.3 Charge Process

The IP2332 uses a full trickle/constant/constant voltage charging mode.

When the battery voltage is less than the trickle to constant current voltage  $V_{TK}$ , it is charged with trickle charging current  $I_{TK}$ .

When the battery voltage is greater than  $V_{TK}$ , charge with constant current charging current  $I_{CC}$ .

When the battery voltage approaches the set constant voltage charging voltage  $V_{CV}$ , the charging voltage  $V_{CV}$  remains unchanged, the charging current slowly decreases, and the constant voltage charging mode is entered.

After entering the constant voltage charging mode, if the charging current is less than the full charge stop detection current  $I_{STOP}$ . The charging will be stopped first, and then detect whether the battery voltage is higher than the stop voltage  $V_{SV}$ . If it is higher than the charging stop voltage  $V_{SV}$ , stop charging. If the stop voltage is lower, charging continues.

After the battery is fully charged and stopped, and the input  $V_{IN}$  continues to be active, if the battery voltage is less than  $V_{RC}$ , it will enter the full charge stage and start the charging process again.

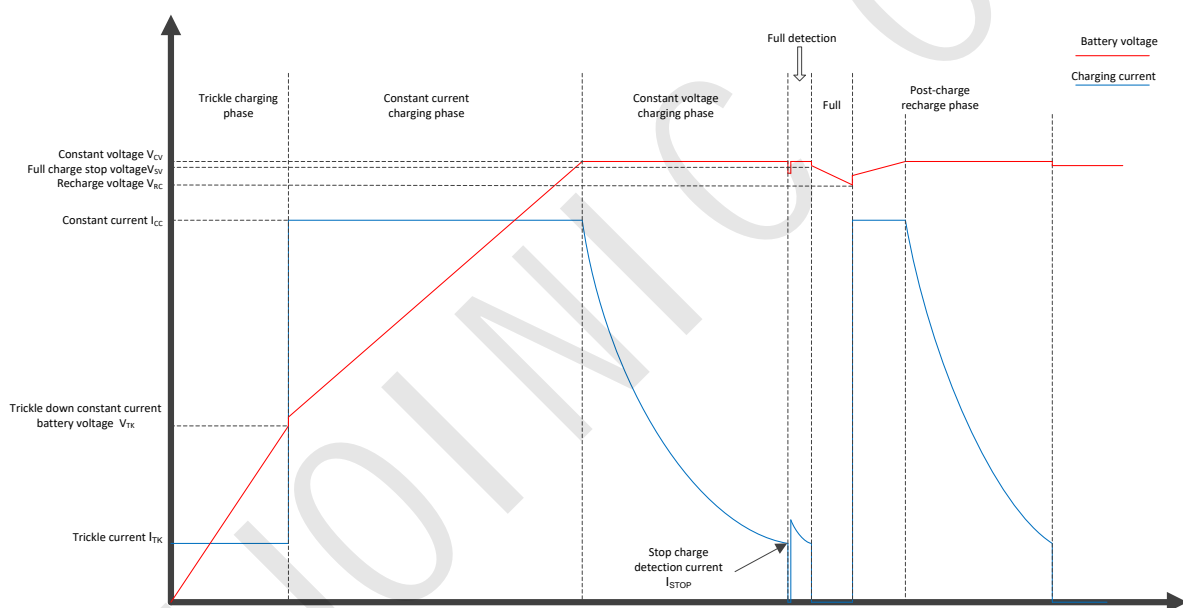


Figure 7 IP2332 Schematic diagram of the charging process

## 10.4 Charging protection

IP2332 has perfect protection functions, integrated input undervoltage, overvoltage protection, NTC temperature protection, IC over temperature protection and other functions to ensure stable and reliable system work.

IP2332 has input voltage regulation loop, which automatically lowers the charging current when it detects that the input voltage is close to the undervoltage threshold of 4.3V, ensuring that the input voltage is stable near the input undervoltage threshold and ensuring that the adapter will not fail.

IP2332 integrates an input overvoltage protection function that stops charging when it detects an input voltage greater than the 6V overvoltage threshold.

IP2332 integrated NTC function, with NTC resistor, can detect the battery temperature, when it is too high or too low, the system can stop charging. When the battery temperature is detected to be medium-low or medium-high, the charging current can be reduced or the charging voltage can be reduced.

IP2332 integrated over-temperature protection function, when the chip internal temperature is detected more than 145°C, the system will be forced to stop charging.

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## 10.5 Charge current setting

IP2332 supports an external resistor R<sub>ISET</sub> on the ISET pin to set the constant current charging current, and the relationship between the charging current I<sub>CC</sub> and R<sub>ISET</sub> is:

$$I_{CC} (A) = 0.35 + 2.75/R_{ISET}(K\Omega).$$

R <sub>ISET</sub> (Ω)	Constant current charging current
1.4K	2.4A
2.4K	1.5A
4.3K	1.0A
NC (≥120K)	2.0A

## 10.6 NTC

IP2332 supports NTC protection function which can cooperate with NTC resistance to detect battery temperature;

IP2332 puts out 30/100uA current through the NTC pin, then detects the voltage generated by this current on the NTC resistor to determine the temperature high or low, and turns off charging when the detected temperature exceeds the set temperature.

The default is to put out 100uA current, and when the pin voltage is detected to be greater than 1.5V (NTC resistance is greater than 15K), the output current is reduced to 30uA. at 30uA output, when the pin voltage is detected to be less than 0.3V (NTC resistance is less than 10K), the output current becomes 100uA.

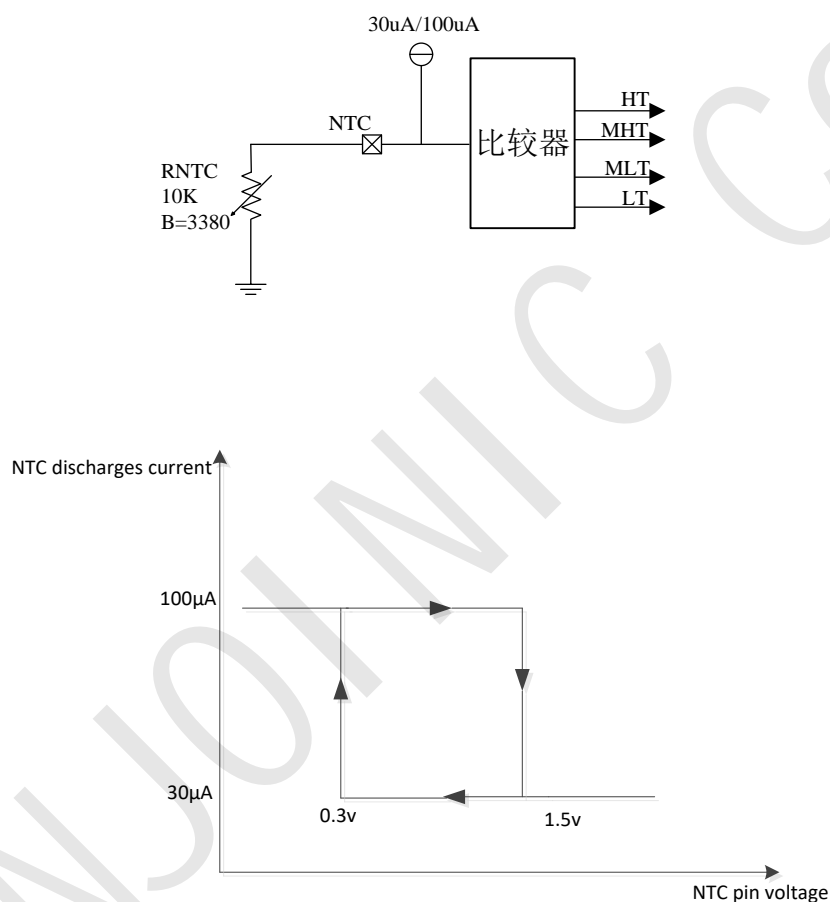


Figure 8 NTC

When IP2332 detects that the NTC pin voltage rises to 0.82V@30uA, it triggers the low temperature protection and stops charging;

When IP2332 detects that the NTC pin voltage is between 0.54V@30uA~0.82V@30uA, it triggers the medium-low temperature protection and the charging current is reduced to half;

When IP2332 detects NTC pin voltage between 0.49V@100uA~0.54V@30uA, it indicates that the battery temperature is normal and normal charging;

When IP2332 detects NTC pin voltage between 0.3V@100uA~0.49V@100uA, it triggers medium-high

temperature protection and full voltage CV-100mV;

When IP2332 detects that the NTC pin voltage drops to less than 0.3V@100uA, trigger high temperature protection and stop charging;

If NTC function is not required, connect the NTC pin to ground with a 10K resistor.

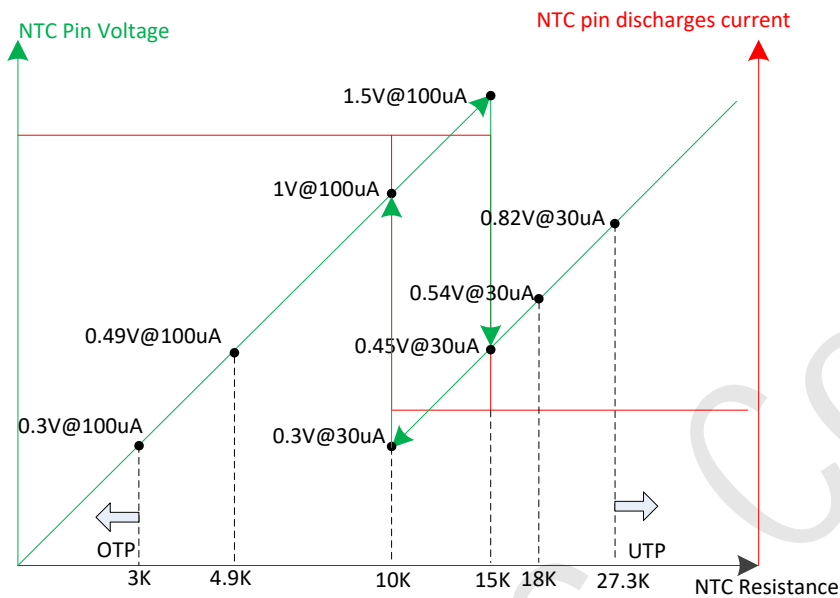


Figure 9 Relationship between NTC voltage and NTC resistance

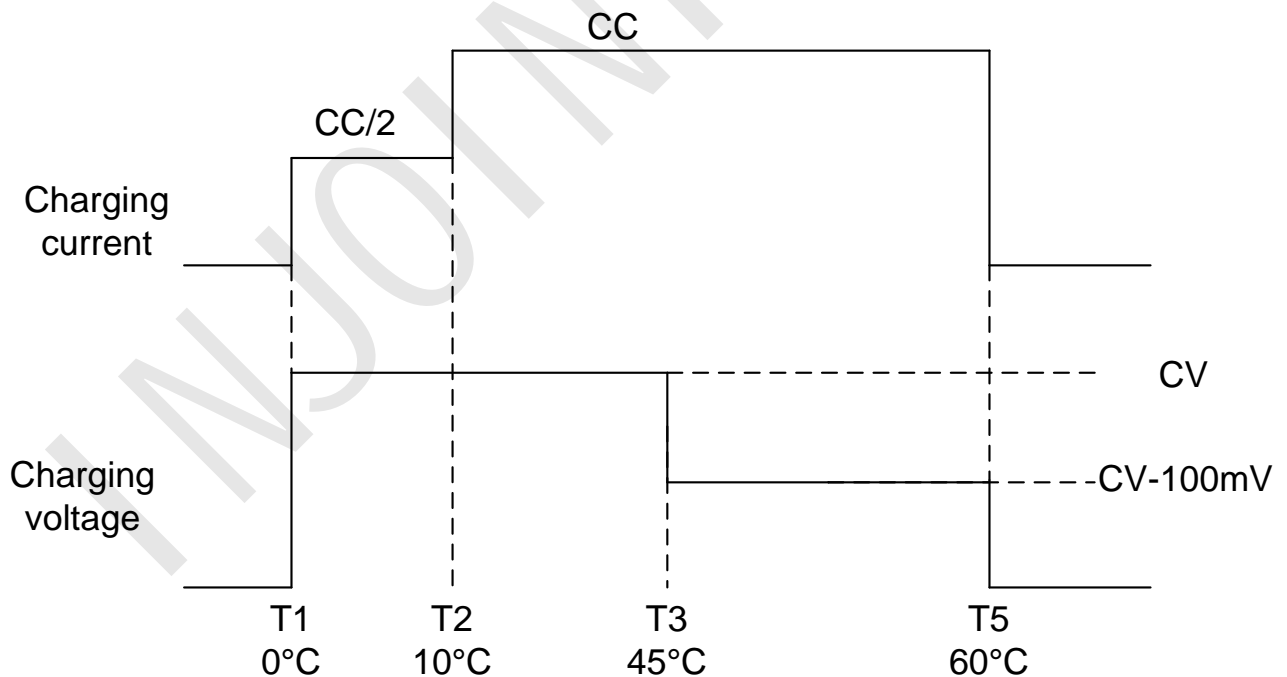


Figure 10 Schematic diagram of 5-segment battery temperature charge protection (JEITA compliant)

## 10.7 Charging LED indication

IP2332 has two LED indicators, LED1 is on and LED2 is off during charging, and LED1 is off and LED2 is on when fully charged. When an abnormality is detected (including input over-voltage protection, NTC protection, and chip over-temperature protection), LED1 and LED2 flash at the same time (500ms on, 500ms off).

IP2332 has battery detection function, when only VIN is connected but not connected to the battery, LED1 and LED2 will flash alternately (LED1 is on for 60ms, off for 150ms, LED2 is on for 150ms, off for 60ms) to indicate abnormality; When the LED of the unconnected battery flashes abnormally, it will enter the normal charging process after connecting the battery.



## 11 Typical Application Schematic

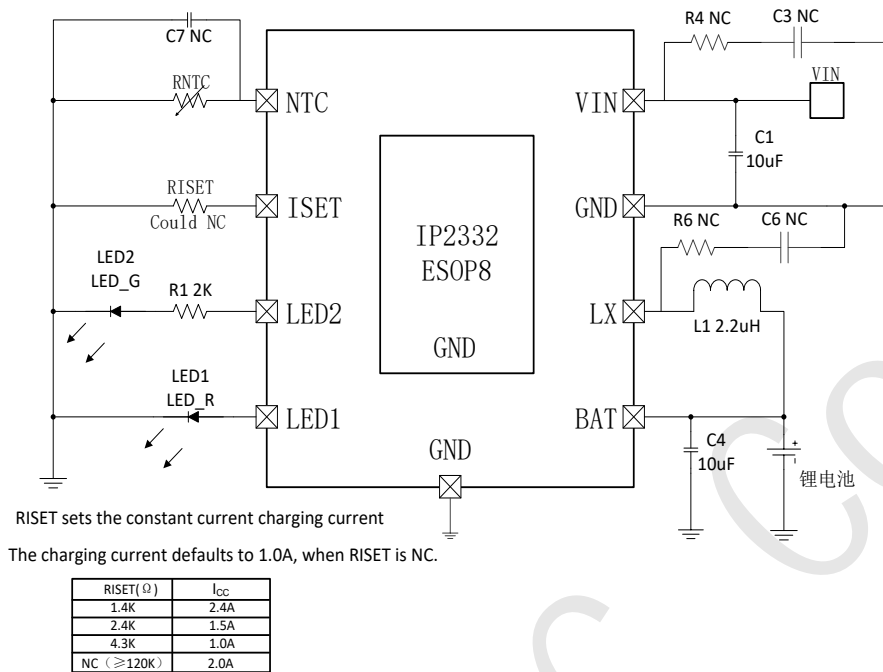


Figure 11 Typical Application Schematic

## 12 BOM

No.	Part Name	Type & Specification	Units	Quantity	Location	Note
1	IC	IP2332	PCS	1	U1	
2	Inductance	CD43	PCS	1	L1	Saturate current (Isat), temperature rise current (Idc) larger than 3.5A, DCR less than 20mΩ, inductance 2.2uH @ 500kHz
3	SMD capacitors	0805 10uF 16V 10%	PCS	2	C1、C4	SMD ceramic capacitor is required
4	SMD capacitors	0603 NC	PCS	3	C3、C6、C7	Certified reservations
5	SMD resistors	0603 NC	PCS	2	R4、R6	Certified reservations
6	SMD resistors	0603 2K 5%	PCS	1	R1	Adjust LED2 brightness
7	LED	0603	PCS	2	LED1 、LED2	LED indicator

8	NTC resistors	NTC 10K B=3380	PCS	1	RNTC	When not in use, connect 10K resistor to ground
9	SMD resistors	0603 NC	PCS	1	RISCT	Set the constant current charging current. Select as needed

## 13 Silkscreen



Instructions:


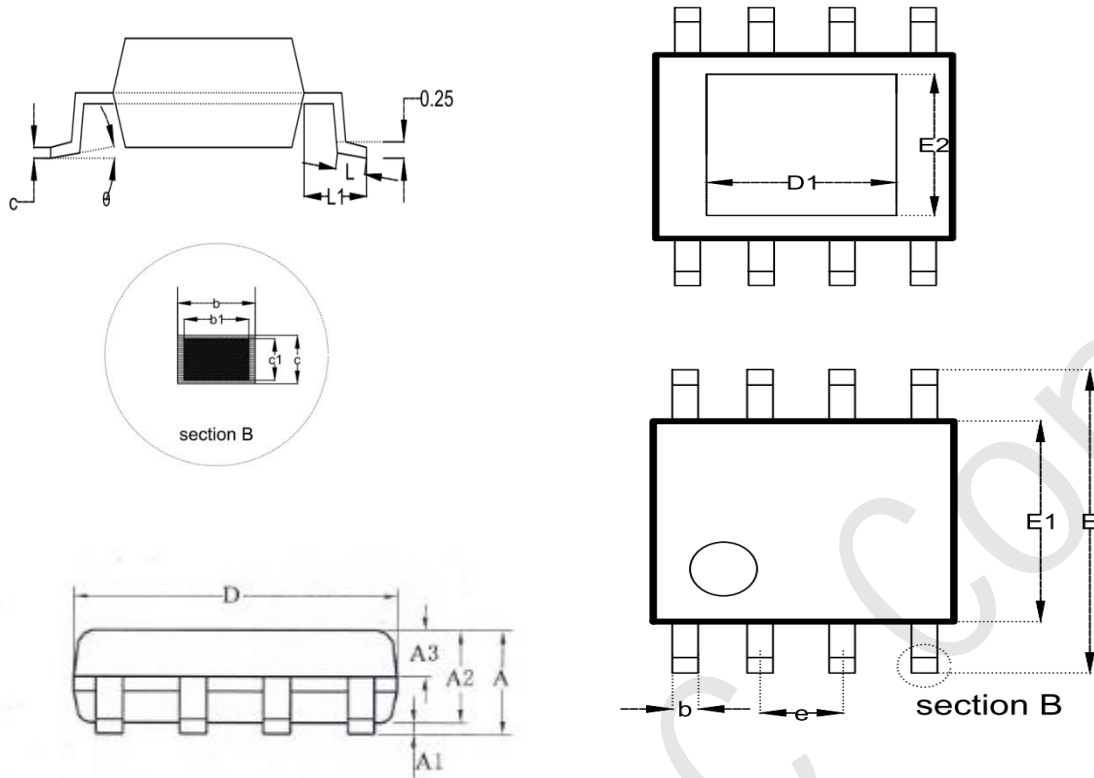
- 1、 --Injoinic logo
- 2、IP2332 --Product name
- 3、XXXXXXXX --Product number
- 4、○ --PIN1 position

Figure 12 SilkScreen

## 14 Package



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	--	--	1.65
A1	0.05	--	0.15
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.39	--	0.48
b1	0.38	0.41	0.43
c	0.21	--	0.25
c1	0.19	0.20	0.21
D	4.70	4.90	5.10
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	1.27BSC		
L	0.50	0.60	0.80
L1	1.05BSC		
θ	0	--	8°
D1	--	3.10	--
E2	--	2.21	--

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