# 3 series lithium battery step-down charging IC

## 1 Feature

- Built-in power MOS
- Working input voltage range: 15V to 24V
- Support 3 series lithium-ion battery charging
- Charging current of 1.5A, customized to support up to 3A charging
- 450kHz switching frequency
- Support charging NTC temperature protection
- Support external resistor to adjust input under voltage protection voltage
- Support LED charging status indication
- Input overvoltage and undervoltage protection
- Over-temperature protection
- ESD 4kV

## 2 Application

- lithium battery charging

## 3 Introduction

IP2364 is a step-down converter with integrated synchronous switch, supporting 3 series lithium battery step-down charging management IC.

IP2364 built-in power MOS, adopts synchronous switch architecture, switching frequency 450kHz, conversion efficiency up to 93%.

The operating input voltage range of IP2364 is 15V to 24V, and it supports an external resistor to adjust the input undervoltage protection voltage. After the input voltage drops to the set undervoltage protection voltage, the charging current is automatically reduced.

The standard IP2364 charging current is 1.5A, and it can support a maximum of 3A charging current through customization.

IP2364 supports NTC function, which can realize charging NTC temperature protection through external NTC resistor.

IP2364 has a soft start function, which can prevent the inrush current at start from affecting the stability of the input power supply.

IP2364 has multiple protection functions, including input over-voltage and under-voltage protection, output over-current, short-circuit protection, etc.

ESOP8 package.



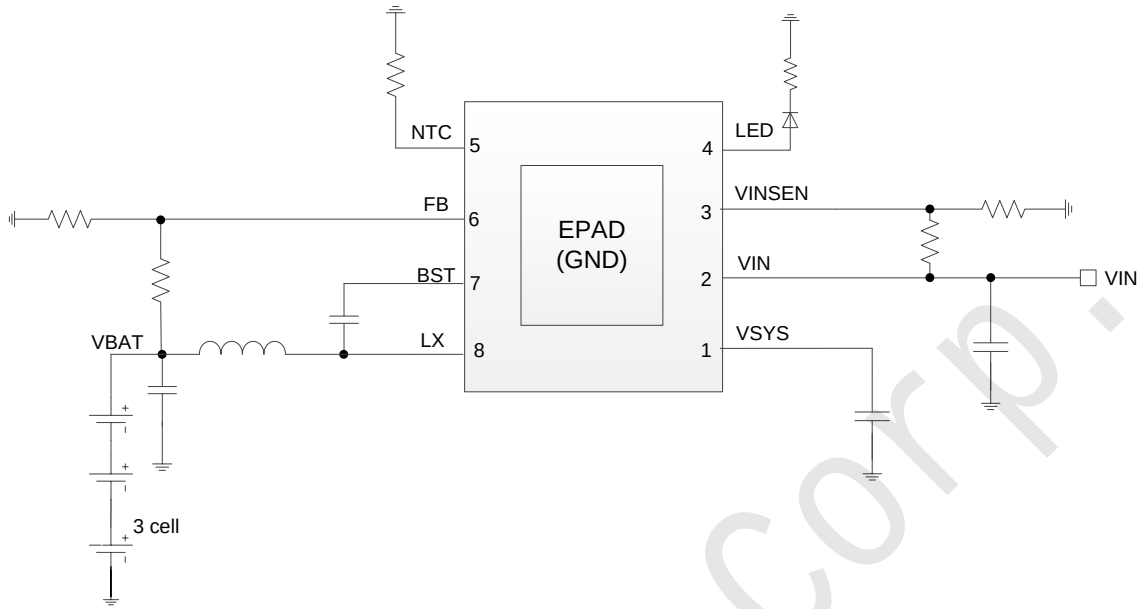



Figure 1 IP2364 simplified application schematic diagram



# Contents





# 4 Reversion History

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

**Initial release version V1.00 (December 2022)**

| Changes from Revision V1.10 to Revision V1.10 (July 2023) | Page |
|---|---|
| ● Add explanation of stop charging current parameters | 7 |



## 5 Pin Configuration And Function

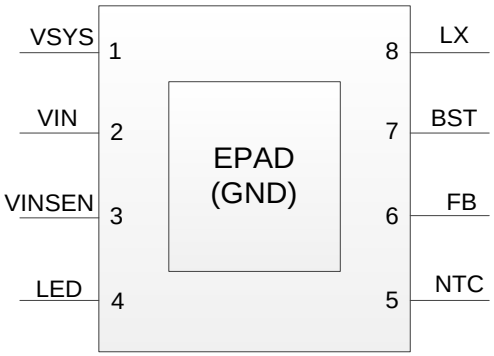



Figure 2 IP2364 pin diagram

| PIN Num | PIN Name | Description |
|---|---|---|
| 1 | VSYS | System voltage pin, connected to a 22uF capacitor near the IC |
| 2 | VIN | Input voltage pin |
| 3 | VINSEN | Input voltage detection pin, can be used as an enable pin |
| 4 | LED | Charging status indicator light output pin |
| 5 | NTC | NTC temperature protection, connect NTC resistance |
| 6 | FB | Output voltage feedback pin |
| 7 | BST | Bootstrap circuit pins, close to the chip BST pin and SW pin to place a bootstrap capacitor to provide voltage for the gate drive of the upper tube |
| 8 | LX | DCDC switch node, connected to the inductor |
| EPAD | GND | Power ground and heat dissipation ground, need to keep good contact with GND |

## 6 IP Comparison Table

The commonly used customized models are as follows:

| Customized model name | description |
|---|---|
| IP2364 | Standard product, 3 series charging, battery terminal 1.5A constant current charging current |



## 7 limit parameters

| parameters | symbol | Value | unit |
|---|---|---|---|
| VIN voltage range | $V_{IN}$、$V_{SYS}$ | -0.3 ~ 28 | V |
| LX voltage range | $V_{LX}$ | -0.3 ~ $V_{IN}$+0.3 | V |
| BST voltage range | $V_{BST}$ | $V_{LX}$+7V | V |
| LED/NTC/ICHG voltage range | $V_{LED/NTC}$ | -0.3 ~ 6 | V |
| Junction Temperature Range | $T_J$ | -40 ~ 150 | ℃ |
| Storage Temperature Range | Tstg | -60 ~ 150 | ℃ |
| Junction Temperature(junction to ambient) | $\theta_{JA}$ | 60 | ℃/W |
| Human Body Model(HBM) | ESD | 4 | kV |

* Stress higher than the values listed in the Absolute Maximum Ratings section may cause permanent damage to the device. Excessive exposure under any absolute maximum rating conditions may affect the reliability and service life of the device

## 8 Recommended working conditions

| parameter | symbol | Min | Typical value | Max | unit |
|---|---|---|---|---|---|
| Input voltage | $V_{IN}$ | 14 | 20 | 24 | V |

* Beyond these operating conditions, device operating characteristics cannot be guaranteed.

## 9 Electrical characteristics

Unless otherwise specified，L=10uH，$V_{IN}$=20V，$V_{BAT}$=10.8V

| Parameter | Symbol | Test Conditions | Min | Typical value | Max | Unit |
|---|---|---|---|---|---|---|
| Input voltage | $V_{IN}$ | | 14 | 20 | 24 | V |
| Input overvoltage threshold | $V_{IN-OV}$ | Rising voltage | 26 | 27 | 28 | V |
| | | drop-out voltage | 24 | 25 | 26 | V |
| Input quiescent current | $I_{VIN\_Q}$ | $V_{IN}$=20V，$I_{BAT}$=0A | | 10 | 20 | mA |
| stand-by current | $I_{BAT\_standby}$ | $V_{IN}$=0V，$V_{BAT}$=12.6V | | 20 | 30 | uA |
| | | $V_{IN}$=20V，$V_{BAT}$=12.6V，Full stop | | 40 | 60 | uA |
| | | $V_{IN}$=20V，$V_{BAT}$=12.6V，$V_{INSEN}$=0V | | 20 | 30 | uA |



| | | | | | | |
|---|---|---|---|---|---|---|
| Charging target voltage | $V_{TRGT}$ | FB pin voltage during CV charging | 2.05 | 2.1 | 2.15 | V |
| charging current | $I_{CHRG}$ | Standard product $V_{IN}$=20V,.$V_{BAT}$=10.8V | | 1.5 | | A |
| Stop charging current | $I_{STOP}$ | $V_{IN}$=20V | | 300 | | mA |
| Trickle cut-off voltage | $V_{TRKL}$ | Detect FB pin voltage | 1.45 | 1.5 | 1.55 | V |
| Trickle charge current | $I_{TRKL}$ | | 40 | 70 | 100 | mA |
| Recharge threshold | $V_{RCH}$ | Detect FB pin voltage | | 2.05 | | V |
| Input undervoltage protection | $V_{UVLO}$ | Detect VINSEN pin voltage | | 1.3 | | V |
| NMOS on resistance | $R_{DS(ON)}$ | | | 60 | 70 | mΩ |
| NMOS on resistance | $R_{DS(ON)}$ | | | 50 | 60 | mΩ |
| LED output current | $I_{LED}$ | | | 5 | 10 | mA |
| operating frequency | $F_S$ | $V_{IN}$=20V, IBAT=1.5A | 400 | 450 | 500 | kHz |
| Thermal Shutdown Temperature | $T_{OTP}$ | Rising temperature | 120 | 140 | 160 | ℃ |
| Thermal Shutdown Temperature Hysteresis | $\Delta T_{OTP}$ | | 30 | 40 | 50 | ℃ |



# 10 Function description

## 10.1 Internal block diagram

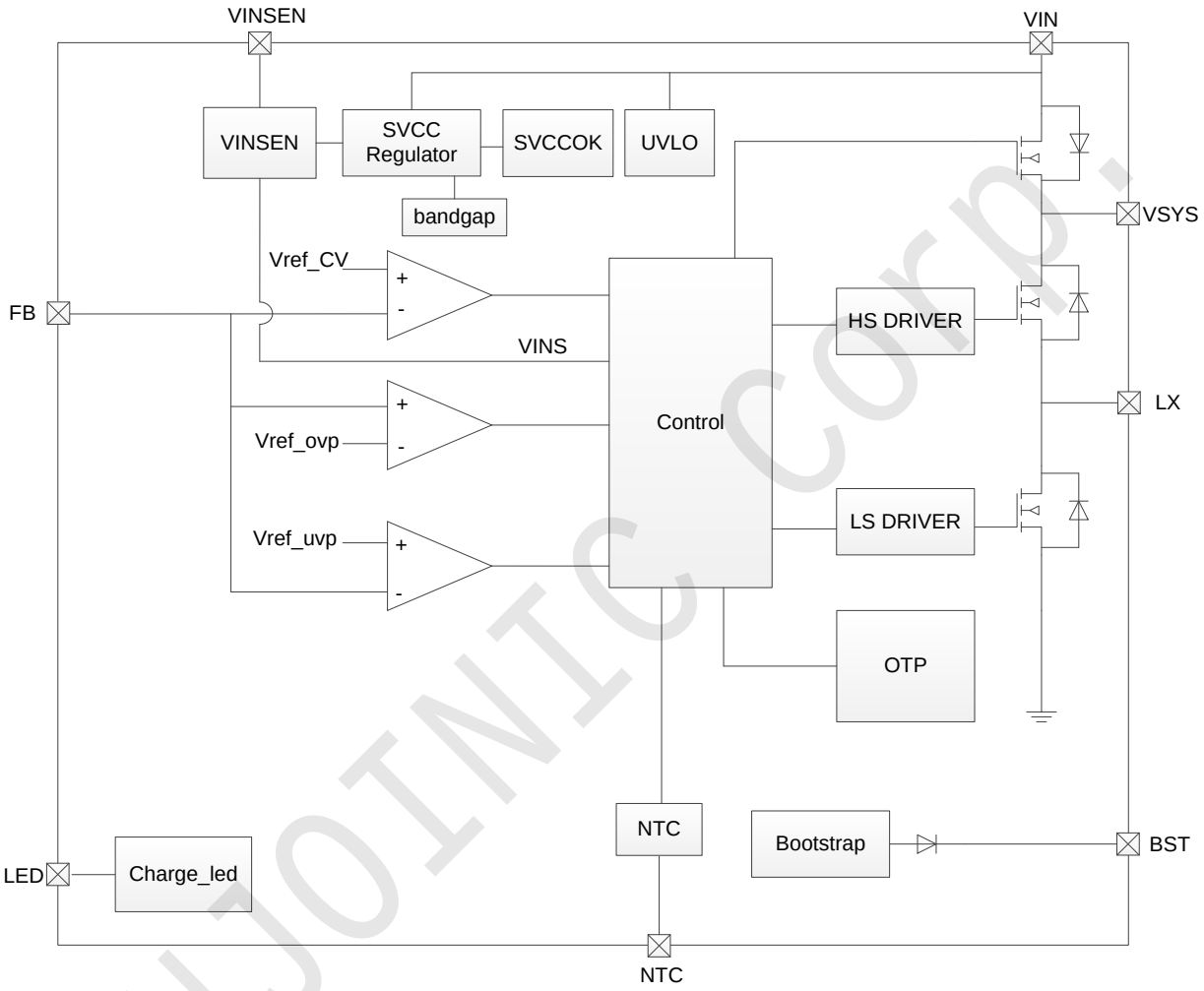



Figure 3 IP2364 internal block diagram

## 10.2 Synchronous switching buck converter

IP2364 integrates a synchronous switch buck converter. The input voltage range is 15V~24V, and the maximum charging current is 3 A. IP2364 has a built-in power switch tube, and the switching frequency during operation is 450kHz. When VIN=12V, VBAT=10.8V@1.5 A, the conversion efficiency is 93%。

IP2364 is a step-down charging method, so the input voltage is required to be at least 0.8V higher than the maximum output voltage.



## 10.3 Charging efficiency

The charging efficiency curve of the 3-series battery is as follows:

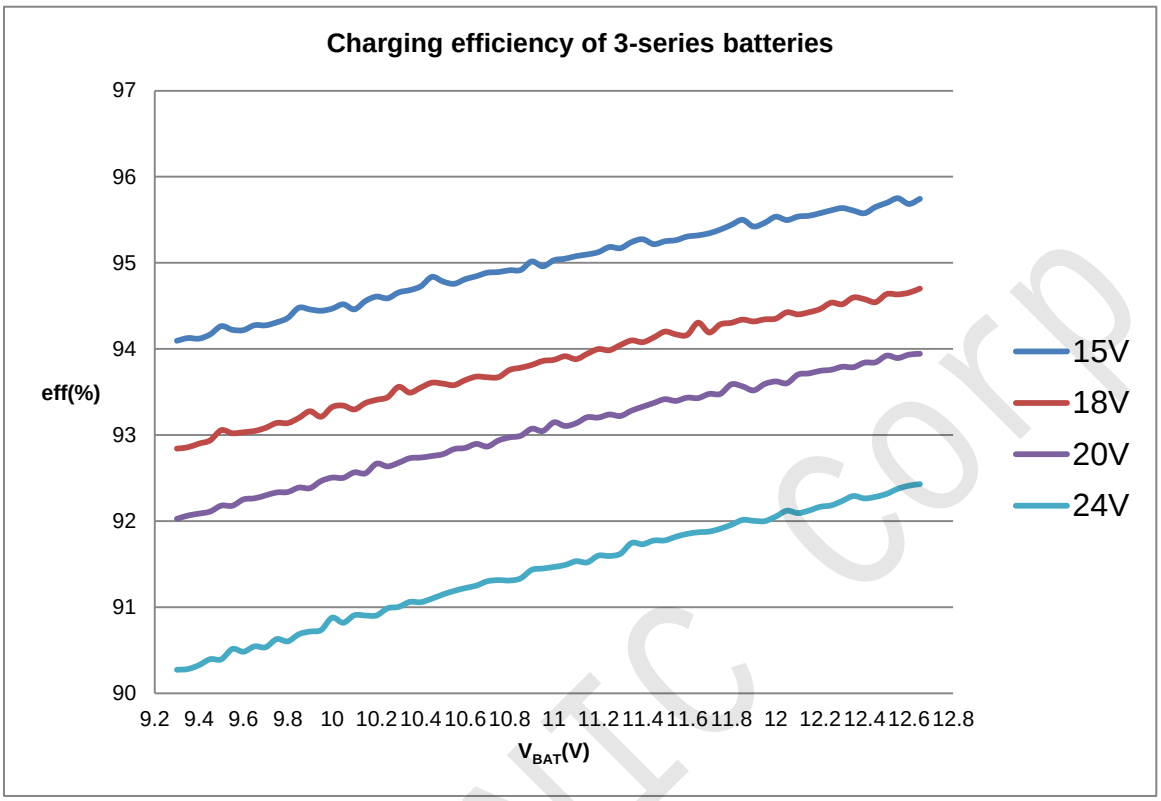



Figure 4 Charging efficiency curve



## 10.4 Charging process

The IP2364 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 VIN 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.

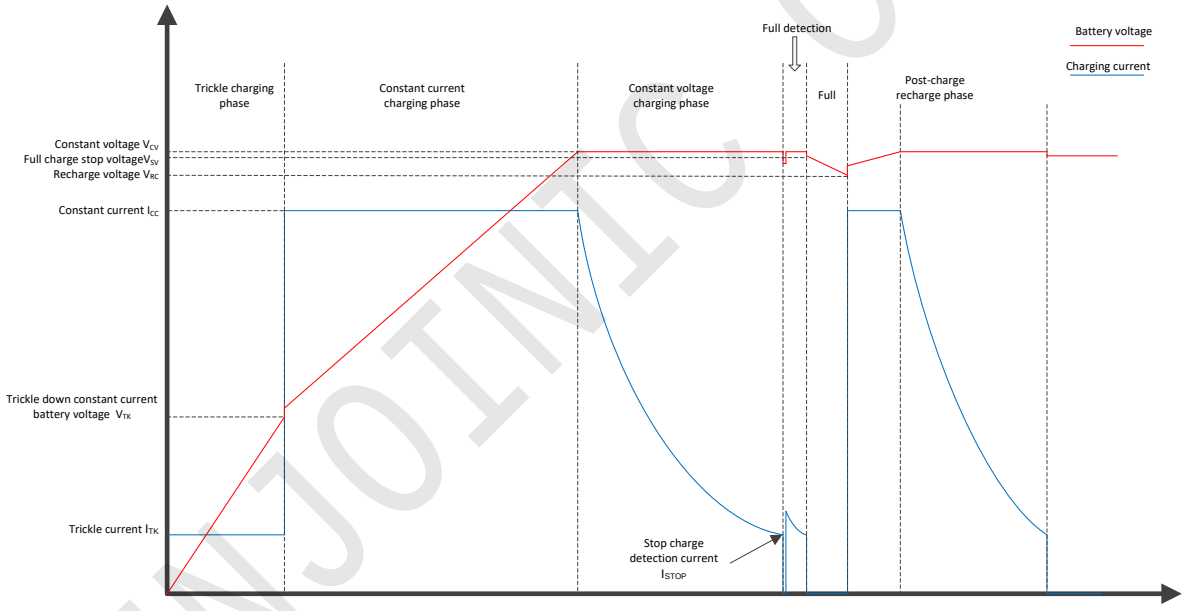



Figure 5 IP2364 Schematic diagram of the charging process

## 10.5 Charging current

The charging current of IP2364 is set by the factory. During constant current charging, when VINSEN voltage is greater than 1.5V and the battery voltage is at the constant current charging stage, it will charge the battery with a charging current of 1.5A at the battery end.

If you need other charging currents, you need to use a custom model.

## 10.6 Charging NTC

IP2364 supports NTC protection function. It detects the battery temperature through the NTC pin,

and stops charging when the detected temperature exceeds the set temperature.

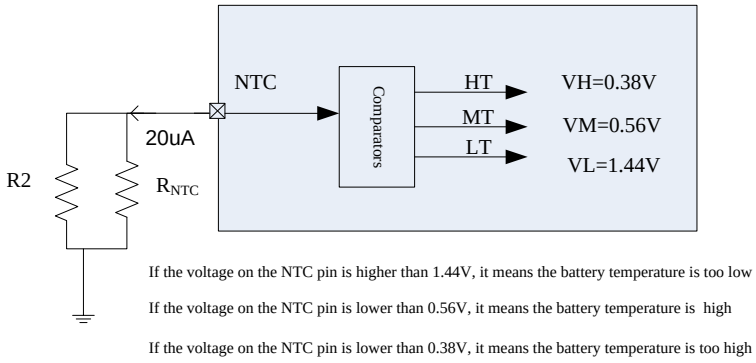



Figure 6 NTC internal schematic diagram

When NTC detects that the temperature is within the range of -10 to 45 degrees, it is charged normally. When the temperature is higher than 45 degrees, the charging current is reduced by half; when the temperature is higher than 60 degrees, the charging is stopped.

If the NTC function is not needed, connect the NTC pin to the ground with a 51k resistor and cannot be left floating。

Discharge 20uA current from NTC, connect a resistor to GND on NTC, the voltage drop generated by this current on the resistor to judge the temperature range。

For example: RNTC=100k@25℃, NTC resistance of B=4100, R2=82k, corresponding temperature and NTC voltage: VNTC=20uA* RNTC *R2 / (RNTC +R2)

| Temperature | 100k@25℃，B=4100 的 NTC temperature resistance value (kΩ) | R2//RNTCresistance (kΩ) | NTC pin voltage (V) The voltage generated by 20uA current on R2//RNTC |
|---|---|---|---|
| -20 | 1105 | 76 | 1.52 |
| -15 | 814 | 74.5 | 1.49 |
| -10 | 606 | 72 | 1.44 |
| 0 | 347 | 66 | 1.32 |
| 45 | 42.1 | 27.8 | 0.56 |
| 50 | 34.8 | 24.5 | 0.49 |
| 55 | 28.5 | 21.2 | 0.43 |
| 60 | 23.5 | 18.3 | 0.38 |

Through customized parameters, the NTC protection temperature can be fine-tuned;



## 10.7 VINSEN sets input undervoltage

IP2364 will detect the VINSEN voltage. If the VINSEN voltage is lower than 1.5V, the charging current will be reduced to stabilize the VINSEN voltage at 1.5V to ensure that the adapter is not pulled dead. When IP2364 detects that VINSEN is lower than 1.3V, it will stop charging and enter standby.

The VINSEN pin can be used as an enable pin to connect to a signal greater than 1.5V and work normally; for a signal less than 1.3V, stop charging and enter standby;

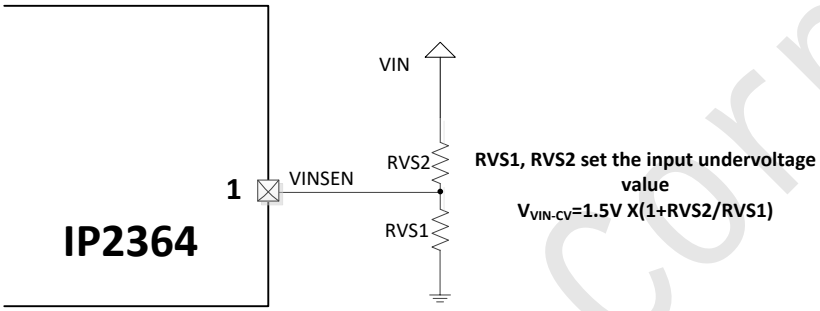



Figure 7 Circuit diagram for undervoltage setting

## 10.8 Protective function

IP2364 has an input overvoltage protection function: when VIN rises above 27V, IP2364 detects input overvoltage and stops charging; when VIN drops to 25V again, IP2364 considers the input normal and restarts charging.

IP2364 has an over-temperature protection function: when IP2364 detects that the chip temperature reaches 140℃, it will stop charging; when the temperature drops to 100℃, IP2364 will consider the temperature to return to normal and restart charging;

## 10.9 Charging instructions

IP2364 supports battery charging LED indicator light. The default configuration is: the LED light stays on during the charging process, turns off when fully charged, and the abnormal LED light flashes.



## 11 Design considerations

1. The VSYS pin must be connected to a 22uF ceramic capacitor, and it cannot be omitted or replaced with an electrolytic capacitor. The 22uF capacitor should be located near the VSYS pin (1 PIN) and the EPAD pin (the GND pin at the bottom of the chip).

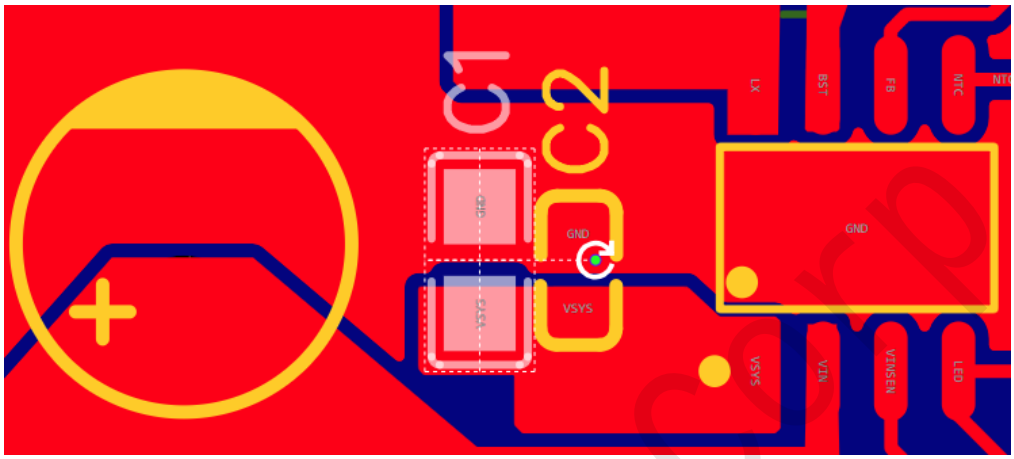



Figure 8 VSYS capacitor LAYOUT



## 12 Typical application schematic

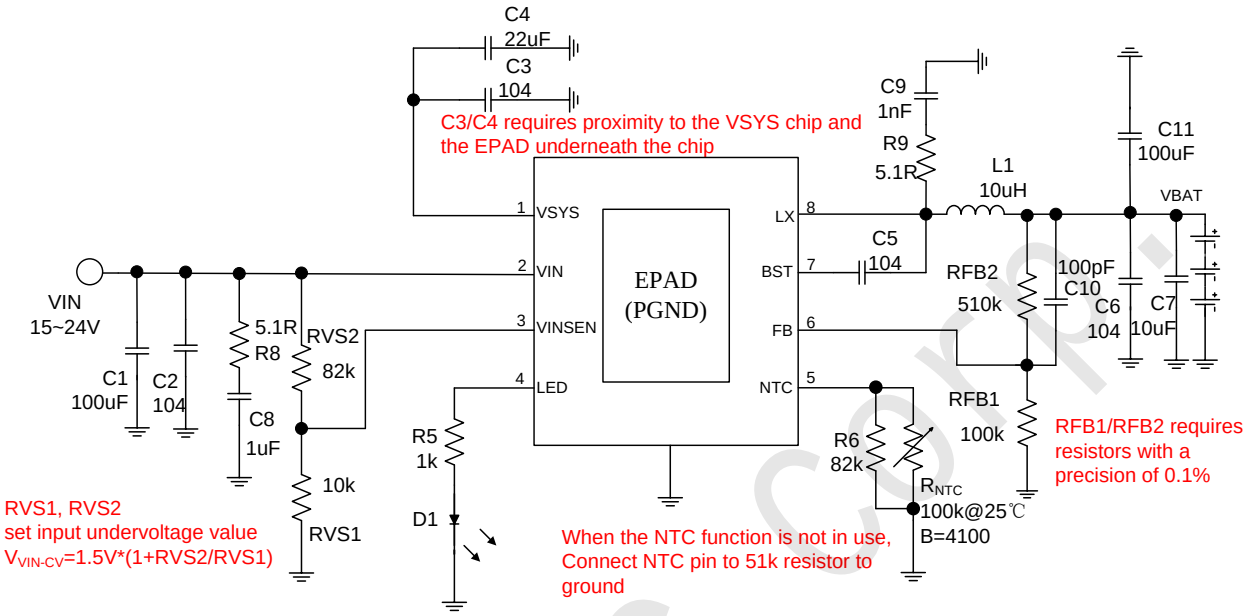



Figure 9 Typical Application Principle Diagram

## 13 BOM

| Num | Component name | Model & Specification | Unit | 用量 | position | Note |
|---|---|---|---|---|---|---|
| 1 | IC | IP2364 | PCS | 1 | U1 | |
| 2 | SMD resistance | 0603 1k 1% | PCS | 1 | R5 | R5 adjusts the brightness of the indicator light |
| 3 | SMD resistance | 0603 82k 1% | PCS | 1 | R6 | When NTC function is not used, use 51k resistor |
| 4 | NTC resistance | 100k@25℃, B=4100 | PCS | 1 | $R_{NTC}$ | NTC resistance |
| 5 | SMD resistance | 0603 10k 1% | PCS | 1 | RVS1 | Set input undervoltage threshold |
| 6 | SMD resistance | 0603 82k 1% | PCS | 1 | RVS2 | Set input undervoltage threshold |
| 7 | SMD resistance | 0603 100k 0.1% | PCS | 1 | RFB1 | RFB1 and RFB2 are required to set the fully charged voltage with an accuracy of 0.1% |
| 8 | SMD resistance | 0603 510k 0.1% | PCS | 1 | RFB2 | RFB1 and RFB2 are set to full voltage and require an accuracy of 0.1% |
| 9 | SMD resistance | 0603 5.1R 1% | PCS | 2 | R8、R9 | |
| 10 | inductance | 10uH | PCS | 1 | L1 | The rated current is required to be greater than 1.5 times the battery terminal charging current |
| 11 | SMD LED | 0603 | PCS | 1 | D1 | SMD LED indicator |
| 12 | SMD capacitors | 0603 104 50V 10% | PCS | 4 | C2、C3、C5、C6 | |
| 13 | SMD capacitors | 0603 1uF 50V 10% | PCS | 1 | C8 | |
| 14 | SMD capacitors | 0603 1nF 50V 10% | PCS | 1 | C9 | |
| 15 | SMD capacitors | 0603 100pF 50V 10% | PCS | 1 | C10 | |
| 16 | SMD capacitors | 0805 10uF 25V 10% | PCS | 1 | C7 | |
| 17 | SMD capacitors | 0805 22uF 25V 10% | PCS | 1 | C4 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 18 | Electrolytic capacitor | 100uF/25V | PCS | 2 | C1、C11 | If the input voltage is low, capacitors with lower withstand voltage can be used |

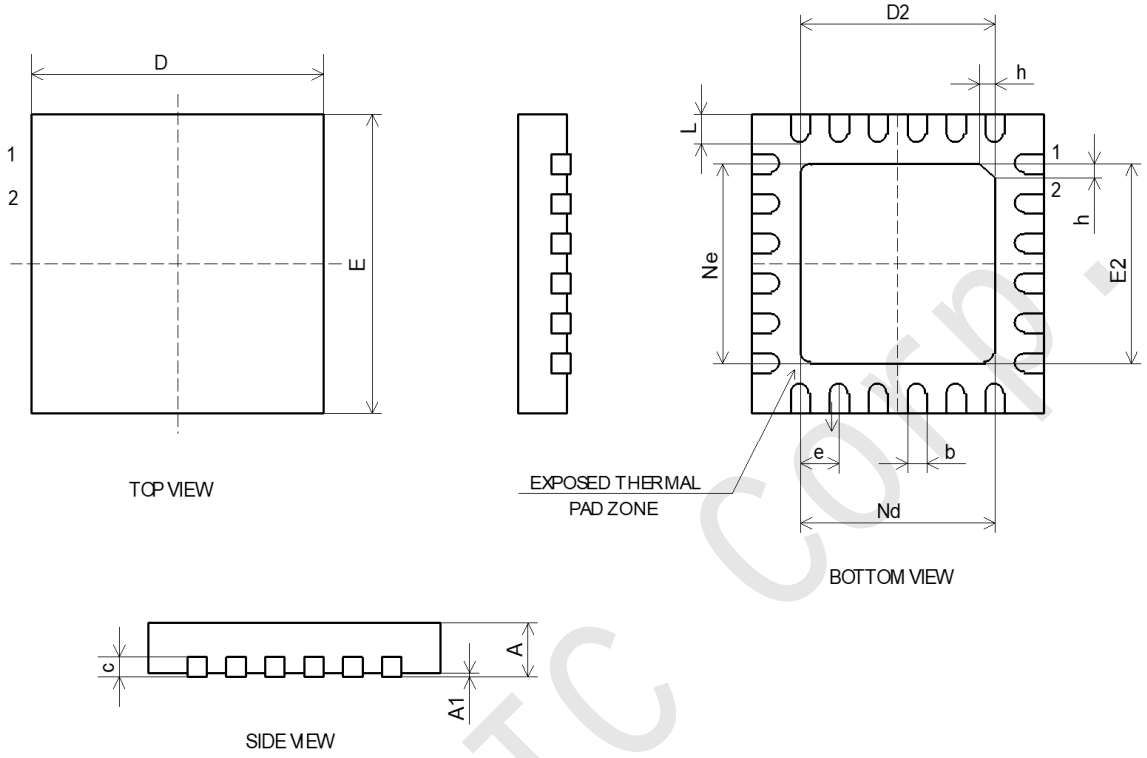
## 14 MARK DESCRIPTION


instruction:

1、 --Injoinic Logo
2、IP2364 --Product Model
3、XXXXXXX --Manufacture Number
4、 ○ --PIN1 Location

Figure 10 IP2364 chip silk screen illustration

## 15 PACKAGE INFORMATION




| SYMBOL | MILLIMETER | | |
|---|---|---|---|
| | MIN | NOM | MAX |
| A | 0.70 | 0.75 | 0.80 |
| A1 | - | 0.02 | 0.05 |
| b | 0.18 | 0.25 | 0.30 |
| c | 0.18 | 0.20 | 0.25 |
| D | 3.90 | 4.00 | 4.10 |
| D2 | 2.40 | 2.50 | 2.60 |
| e | 0.50BSC | | |
| Ne | 2.50BSC | | |
| Nd | 2.50BSC | | |
| E | 3.90 | 4.00 | 4.10 |
| E2 | 2.40 | 2.50 | 2.60 |
| L | 0.35 | 0.40 | 0.45 |
| h | 0.30 | 0.35 | 0.40 |

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