# Ruyun Electronics ***CONSONANCE***

Lithium iron phosphate battery charging management chip powered by solar panels

# CN3158

## Overview:

CN3158 is a single-cell lithium iron phosphate battery charge management chip that can be powered by solar panels. The device includes a power transistor inside, and no external current sense resistor and blocking diode are required for application. The internal charging current adaptive module can automatically adjust the charging current according to the current output capability of the input power supply. The user does not need to consider the worst case, and can maximize the current output capability of the input power supply. It is very suitable for applications powered by power supplies with limited current output capabilities such as solar panels. CN3158 requires only a few peripheral components and is very suitable for portable applications. The thermal modulation circuit can control the chip temperature within a safe range when the device power consumption is relatively large or the ambient temperature is relatively high. The internal fixed constant voltage charging voltage is 3.63V, which can also be adjusted upward by an external resistor. The charging current is set by an external resistor. When the input voltage is powered off, CN3158 automatically enters a low-power sleep mode, and the battery current consumption is less than 3 microamperes. Other functions include input voltage low latch, automatic recharge, battery temperature monitoring, and charging status/charging end status indication.

The CN3158 is available in a thermally enhanced 8-pin small outline package (eSOP8).

## Features:

ÿ An internal integrated charging current adaptive module can automatically adjust the charging current according to the current output capability of the input voltage source ÿ Can be powered by a voltage source with limited output current capability

such as a solar panel ÿ Input voltage range: 4.4V to 6V

ÿ On-chip power transistor ÿ No

external blocking diode and current detection resistor required ÿ Constant

voltage charging voltage of 3.63V can also be adjusted through an external Resistance upward adjustment

ÿ Can be used as a voltage sourceÿ

Internal soft-start circuitÿ In order

to activate deeply discharged batteries and reduce power consumption, trickle charging mode is used when the battery voltage is lowÿ

Continuous constant current charging current can be set up to 1Aÿ

Charging in constant current/constant voltage/constant temperature mode can maximize the charging current and prevent chip overheatingÿ

Automatically enter low-power sleep mode when the power supply voltage is powered offÿ Dual indication outputs for charging status and charging

end statusÿ C/10 charging end

detectionÿ Automatic

rechargingÿ Battery temperature

monitoring functionÿ Package

form eSOP8ÿ The product is lead-free, meets RoHS, and does not contain halogen

## application:

ÿ Solar chargers ÿ Applications

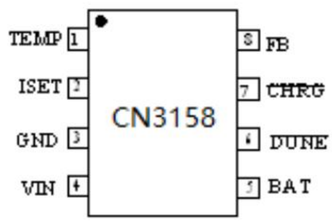
using solar panels ÿ Applications with limited input

power current output capability ÿ Emergency lights ÿ Portable

applications ÿ

Various chargers

## Pin arrangement:



Application Circuit:

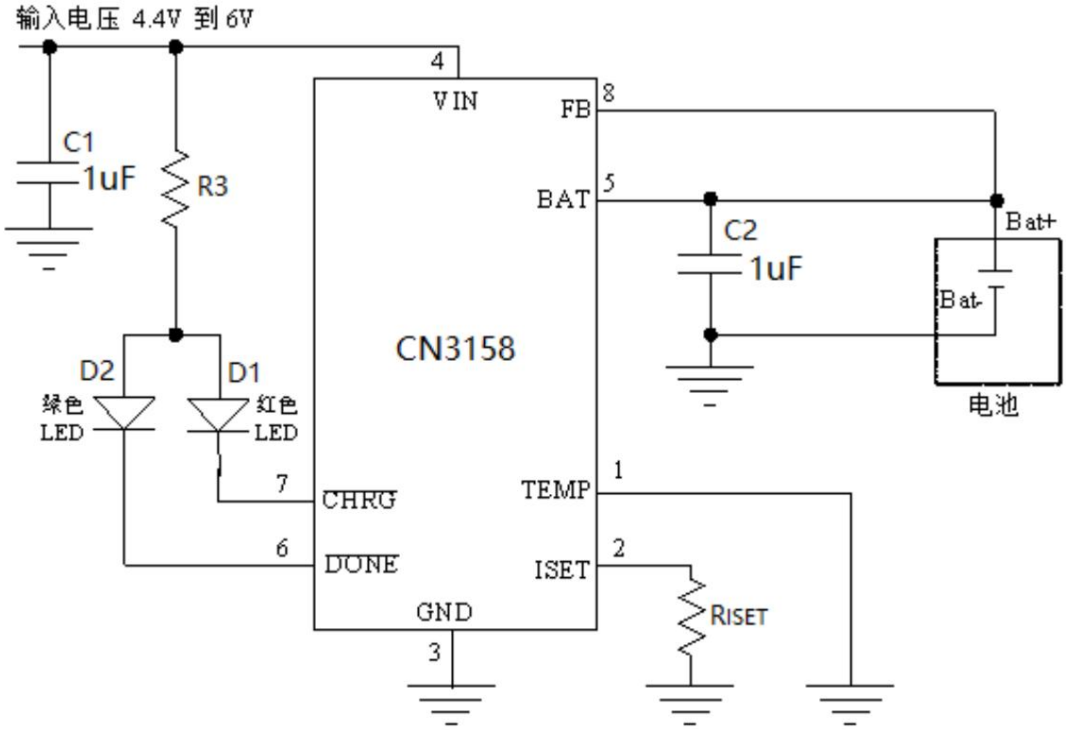



Figure 1 Typical application circuit (constant voltage charging voltage 3.63V)

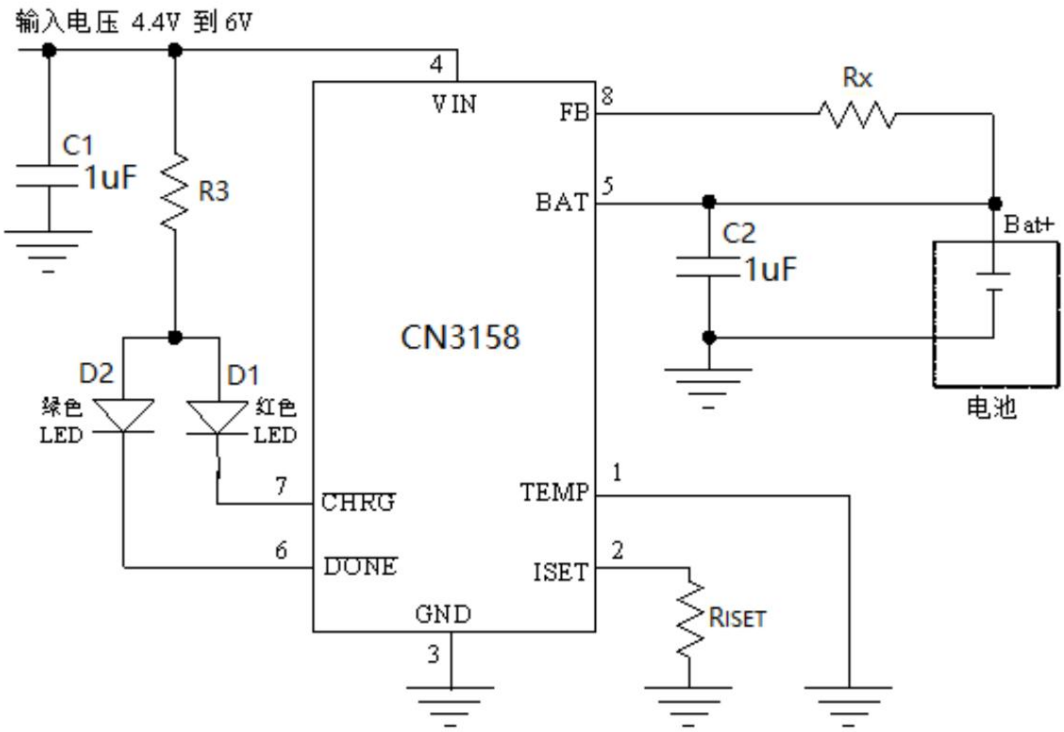



Figure 2 Application circuit (using external resistor to adjust constant voltage charging voltage)

In Figure 2, the constant voltage charging voltage at the positive terminal of the battery is:

VREG = 3.63 + 3.707 × 10-6 × Rx ,
where VREG is in volts

The unit of Rx is Ohm

Note: When using an external resistor to adjust the constant voltage charging voltage, due to the inconsistent temperature inside and outside the chip and the chip production

Process deviations and other reasons may cause the accuracy of the constant-voltage charging voltage to deteriorate and the temperature coefficient to increase.

Ordering Information

| Model | Package eSOP8 | Tape, reel, | range of working temperature |
|---|---|---|---|
| CN3158 | 4000/reel | | -40ÿ to +85ÿ |

Functional Block Diagram:

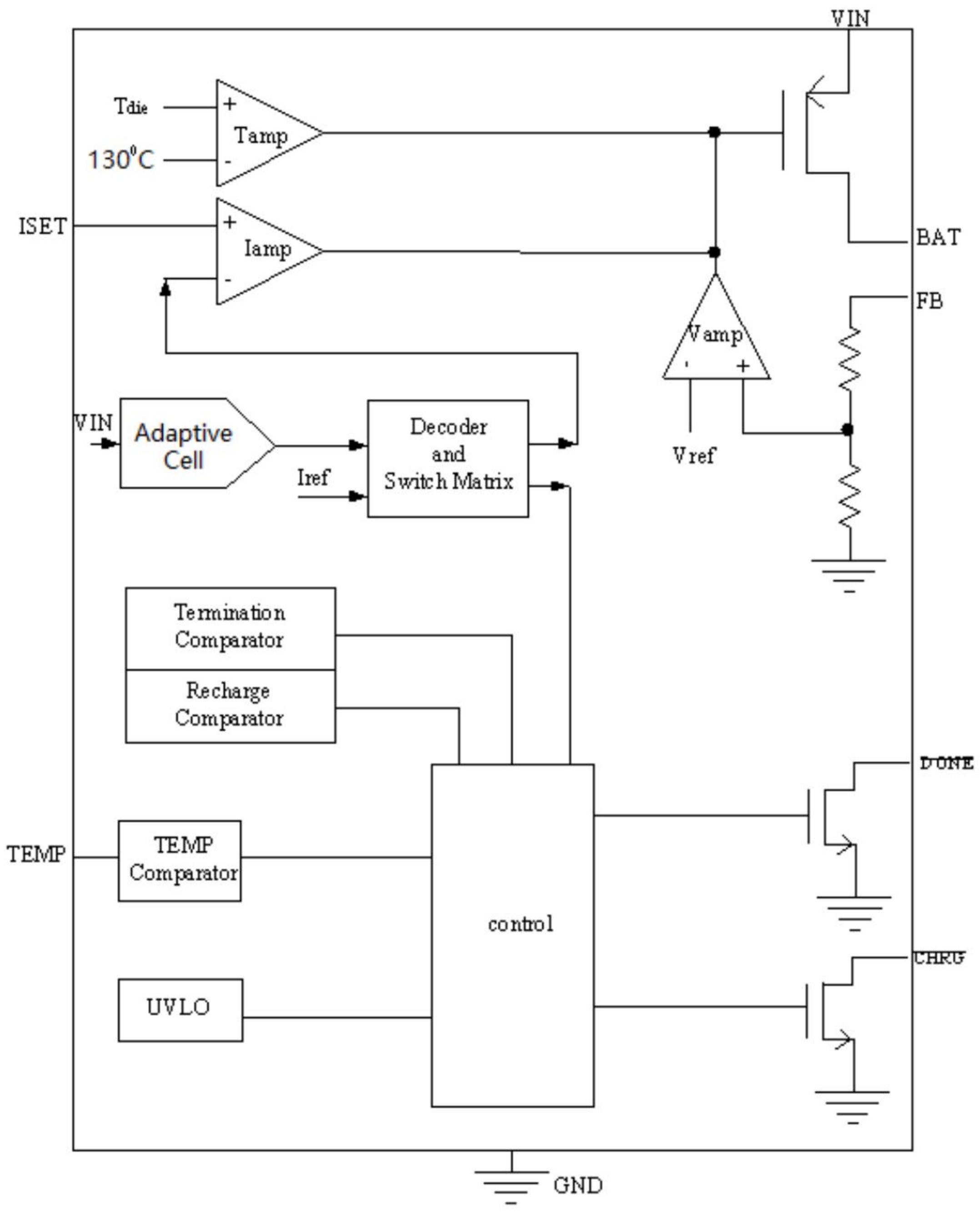



Figure 3 Functional block diagram

## Pin Function Description

| Serial number | name | Functional Description |
|---|---|---|
| 1 | TEMP | Battery temperature detection input terminal. Connect the TEMP pin to the output terminal of the battery's NTC sensor. If the voltage at the TEMP pin is less than 45% of the input voltage or greater than 80% of the input voltage, it means If the battery temperature is too low or too high, charging will be suspended. 80%, the battery fault condition will be cleared and charging will continue. If the TEMP pin is connected to ground, the battery temperature monitoring function will be disabled. |
| 2 | ISET | Constant current charging current setting and charging current monitoring terminal. Connect an external resistor from the ISET pin to ground During the trickle charge phase, the voltage on this pin is modulated at 0.12V; in the constant current charging stage, the voltage of this pin is modulated at 1.205V. In any mode, the voltage of this pin can be used to monitor the charging current according to the following formula: ICH = (VISET×986)ÿRISET |
| 3 | GND | Power Ground |
| 4 | VIN | Input voltage positive input terminal. The voltage of this pin is the working power supply of the internal circuit. When the voltage difference between the pins is less than 10mV, CN3158 will enter a low-power sleep mode. The current drawn by the pin is less than 3μA. |
| 5 | BAT | Battery connection terminal. Connect the positive terminal of the battery to this pin. In the default or sleep mode, the current of the BAT pin is less than 3μA. The BAT pin provides charging current to the battery. current and constant voltage charging voltage. |
| 6 | $\overline{DONE}$ | The open-drain output indicates the end of charging. $\overline{DONE}$ When the switch is pulled to a low level, it indicates that charging is complete; otherwise the $\overline{DONE}$ pin is in a high impedance state. |
| 7 | $\overline{CHRG}$ | The charging status indicator pin is an open-drain output. When the charger is charging the battery, the $\overline{CHRG}$ pin is internally The internal switch is pulled to a low level, indicating that charging is in progress; otherwise the $\overline{CHRG}$ pin is in a high impedance state. |
| 8 | FB | Battery voltage detection input. This pin is used to detect the voltage of the positive electrode of the battery, so as to accurately modulate the constant The voltage of the positive electrode of the battery during charging is avoided from the positive electrode of the battery to the BAT pin of CN3158 The influence of parasitic resistance such as wire resistance or contact resistance on charging. Connecting a resistor between the two pins can adjust the constant voltage charging voltage upwards. |

## Limit parameters

Pin voltage…………………………ÿ0.3V to 6.5V BAT pin short circuit duration………Continuous Storage temperature………ÿ 65ÿ to 150ÿ Soldering temperature (10 seconds)………………260ÿ

Maximum junction temperature……………………150ÿ

Working temperature……………ÿ40ÿ to 85ÿ

Thermal resistance (SOP8)……………………TBD

Exceeding the above-listed limit parameters may cause permanent damage to the device, · The above is only the limit range. Under such limit conditions and the technical indicators of the device will not be guaranteed. Long-term operation under such conditions will also affect the reliability of the device.

Electrical parameters:

(VIN=5V, unless otherwise specified, TA=-40ÿ to 85ÿ, typical values are measured at an ambient temperature of 25ÿ)

| parameter | | Test Conditions | Min.Typ.Max.Unit | | | |
|---|---|---|---|---|---|---|
| Symbol Input supply voltage VIN | | | 4.4 | | 6 | V |
| Operating current | IVIN BAT terminal no-load power | | 350 | 500 | 660 µA | |
| supply low voltage latching threshold Vuvlo VIN falling power | | | | 2.4 | 2.65 V | |
| supply low voltage latching threshold | Huvlo | | | 0.12 | | V |
| Hysteresis soft start time tSS | | | 100 | 160 | 220 microseconds | |
| Constant voltage charging voltage VREG FB terminal connected to | | | 3.595 | 3.63 | 3.665 V | |
| Battery connection current | ICC | BAT terminal RISET=1.18K, constant current | | 1000 | 1100 | mA |
| | IPRE | charging mode 900 RISET=1.18K, | 75 | 100 | 125 | |
| | VBATÿ2.4V ISLP VIN=0V, sleep mode | | | | 3 µA | |
| Precharge Threshold | | | | | | |
| Precharge Threshold | VPRE FB pin voltage rise pre- | | 67 | 70 | 73 % VREG | |
| charge threshold hysteresis HPRE | | | | 4.2 | | %VREG |
| charge end threshold | | | | | | |
| The charging end threshold Vterm measures the voltage of the ISET pin | | | 96 | 120 | 144 mV | |
| Recharge Threshold | | | | | | |
| Recharge threshold IRECH Charging current rises Sleep | | | | 30 | | %ICC |
| mode | | | | | | |
| Sleep mode threshold VSLP | | VIN drops<br>Measure voltage difference (VIN-VBAT) | 15 | 32 | 50 mV | |
| Sleep mode release threshold VSLPR | | VIN rises<br>Measure voltage difference (VIN-VBAT) | 57 | 80 | 120 mV | |
| **ISET Pin** | | | | | | |
| ISET pin voltage | VISET | VBAT<2.6V, pre-charge mode constant | | 0.12 | | V |
| | | current charge mode | | 1.205 | | |
| FB pin | | | | | | |
| FB input current 1 | IFB1 VFB=3.6V, normal charging state | | 1.8 | 3 | 5 µA | |
| FB input current 2 | IFB2 VIN<Vuvlo or VIN<VBAT | | | | 1 µA | |
| **TEMP Pin** | | | | | | |
| High-side | VHIGH TEMP pin voltage rises | | 77.5 | 80 | 82.5 %VIN | |
| threshold Low- | VLOW TEMP pin voltage drops | | 42.5 | 45 | 47.5 %VIN | |
| side threshold | | Current from TEMP to VIN or to ground | | | 0.5 µA | |
| $\overline{CHRG}$ Input current pin | | | | | | |
| $\overline{CHRG}$ Pull-down | ICHRG VCHRG=0.3V, charging state | | | 10 | | mA |
| $\overline{CHRG}$ current | | VCHRG=6V, charging end state | | | 1 | µA |
| $\overline{DONE}$ leakage pin | | | | | | |
| $\overline{DONE}$ Pull-down current | IDONE VDONE=0.3V, charging is finished | | | 10 | | mA |
| $\overline{DONE}$ leakage current | | VDONE=6V, charging status | | | 1 | µA |

A detailed description

CN3158 is a chip specially designed for charging single-cell lithium iron phosphate batteries using input power sources with limited output current capabilities such as solar panels. The power transistor inside the chip charges the battery with constant current and constant voltage. The charging current is set by an external resistor, and the maximum continuous charging current can reach 1A, without the need for additional blocking diodes and current detection resistors. CN3158 has an integrated charging current adaptive module that can automatically adjust the charging current according to the current output capability of the input power supply. Users do not need to consider the worst case scenario. The charging current can be set according to the maximum current output capability of the input power supply, maximizing the current output capability of the input power supply. It is very suitable for charging applications powered by power sources with limited output current such as solar panels. CN3158 contains two open-drain output status indication output terminals, $\overline{CHRG}$ charging status indication terminal and a $\overline{DONE}$ charging end indication output terminal. The power management circuit inside the chip automatically reduces the charging current when the junction temperature of the chip exceeds 130°C. This function allows users to maximize the power handling capacity of the chip without worrying about overheating of the chip and damaging the chip or external components. In this way, when designing the charging current, users do not need to consider the worst case, but only design according to the typical case, because in the worst case, CN3158 will automatically

reduce the charging current. When the input voltage is greater than the low voltage latch threshold and the battery voltage, CN3158 starts to charge the battery, and the $\overline{CHRG}$ pin outputs a low level, indicating that charging is in progress. If the voltage of the battery voltage detection pin (FB) is lower than 70% of the constant voltage charging voltage, CN3158 pre-charges the battery with trickle current. When the voltage of the battery voltage detection pin (FB) exceeds 70% of the constant voltage charging voltage, CN3158 uses constant current mode to charge the battery, and the charging current is set by the resistor RISET between the ISET pin and GND. When the voltage of the battery voltage detection pin (FB) approaches the constant voltage charging voltage, the charging current gradually decreases, and CN3158 enters the constant voltage charging mode. When the battery voltage reaches the constant voltage charging voltage and the charging current decreases to the charging end threshold, the charging cycle ends, the $\overline{CHRG}$ terminal outputs a high impedance state, and the $\overline{DONE}$ terminal outputs a low level, indicating that the charging cycle ends. The charging end threshold is 10% of the constant current charging current. If you want to start a new charging cycle, just turn off the input power supply and then turn it on again. At the end of charging, when the charging current rises to more than 30% of the constant current charging current, a new charging cycle starts automatically. The high-precision voltage reference source, error amplifier and resistor divider network inside the chip ensure that the error of the constant voltage charging voltage is within ±1%, which meets the battery requirements. When the input voltage is powered off or the input voltage is lower than the battery voltage, CN3158 enters a low-power sleep mode, and the current consumed by the battery end is less than 3uA, thereby increasing the standby time. The above charging process is shown in Figure 4:

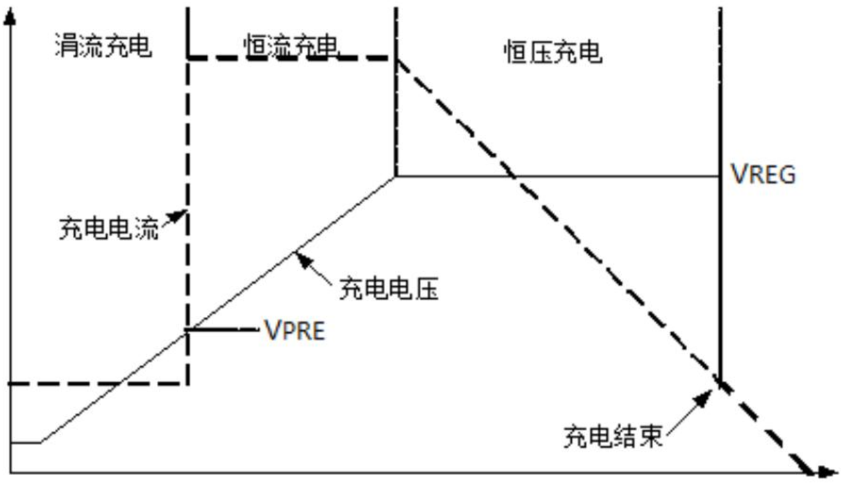



Figure 4 Schematic diagram of the charging process

Application Information

Power supply under voltage lockout (UVLO)

CN3158 has a power supply voltage detection circuit inside. When the power supply voltage is lower than the low voltage threshold, the chip is in the off state and charging is also prohibited. Sleep

mode CN3158 has a sleep state comparator inside. When the input voltage VIN is lower than the sleep mode threshold, CN3158 enters sleep mode; only when the input voltage VIN rises above the sleep mode release threshold, CN3158 leaves sleep mode and enters normal working state.

Input power supply current limiting

mode When the current output capacity (load capacity) of the CN3158 input power supply is less than the set charging current, the charging current adaptive module inside the CN3158 automatically adjusts the charging current according to the current output capacity of the input power supply. At this time, the actual charging current may be less than the set charging current, but under the premise of ensuring that the voltage of the 4th pin VIN of CN3158 is not lower than the minimum operating voltage, the charging current can be maximized. This is the input power supply current limiting mode. In this mode, the user does not need to consider the worst case, as long as the charging current is set according to the maximum current output capacity of the input power supply, so it is very suitable for charging lithium iron phosphate batteries using power supplies with limited current output capacity such as solar panels.

Charging ends in

the constant voltage charging state. When the charging current is less than 1/10 of the set constant current charging current, the charging cycle ends. If the battery voltage does not reach the set constant voltage charging voltage, even if the charging current is less than 1/10 of the set constant current charging current, the charging will not end. Pre-

charge state At the

beginning of the charging cycle, if the voltage of the battery voltage detection pin (FB) is lower than 70% of the set constant voltage charging voltage, CN3158 is in the pre-charge state, and the charger charges the battery at 10% of the constant current charging current. Battery voltage

detection CN3158 has a

battery voltage detection pin (FB), which is connected to the constant voltage charging error amplifier through the precision resistor voltage divider network inside the chip. The FB pin can be directly connected to the positive electrode of the battery, which can effectively avoid the influence of the parasitic resistance (including wire resistance, contact resistance, etc.) between the positive electrode of the battery and the 5th pin BAT of CN3158 on charging. The presence of these parasitic resistances will cause the charger to enter the constant voltage charging state prematurely, prolong the charging time, and even make the

battery not fully charged. If the battery voltage detection pin (FB) of CN3158 is left floating, then CN3158 is always in the pre-charge state, and the charging current is 1/10 of the set constant current charging current.

Adjusting the constant voltage

charging voltage If a resistor is connected between the battery voltage detection pin (FB) of CN3158 and the positive electrode of the battery, the constant voltage charging voltage of the positive electrode of the battery can be increased, as shown in Figure 5.

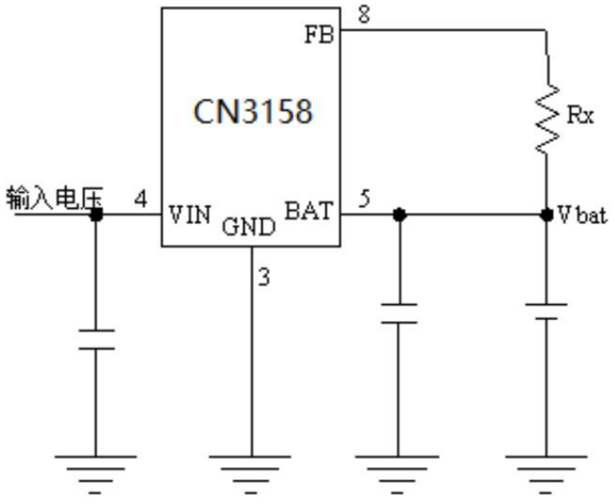



Figure 5 Adjusting the constant voltage charging voltage

If the connection method in Figure 5 is used, the constant voltage charging voltage VREG is:

VREG = 3.63 + 3.707 × 10-6 × Rx ,
where VREG is in volts
and Rx is in ohms

When using an external resistor to adjust the constant voltage charging voltage, due to the inconsistent temperature inside and outside the chip and the process deviation during chip production, Therefore, the accuracy of the constant voltage charging voltage may deteriorate and the temperature coefficient may

increase. Set the constant current charging

current In the constant current charging mode, the formula for calculating the charging current is:

ICH = 1188V / RISET

Where ICH is the charging current in amperes RISET is the

resistance from the ISET pin to ground in ohms For example, if a 1A charging

current is required, it can be calculated using the following formula: RISET = 1188V/1A =

1.188kÿ

In order to ensure good stability and temperature characteristics, RISET recommends using metal film resistors with an accuracy of

1%. The charging current can be detected by measuring the voltage of the ISET pin. The charging current can be calculated using the

following formula: ICH = (VISET / RISET) ×

986 Simultaneously apply two input power supplies to charge the

battery CN3158 can use a variety of input power supplies to charge lithium iron phosphate batteries. These input power supplies can be the voltage output by the USB interface, or a wall adapter, or a solar panel, etc. Figure 6 shows an example of using two of the input power supplies to charge the battery at the same time. When the two are present, the first input power supply has priority. M1 is a P-channel MOSFET. M1 is used to prevent current from flowing from the first input power supply to the second input power supply. The Schottky diode D1 can prevent the second input power supply from consuming energy through the 1K resistor. In practical applications, the first input power supply should be connected to a power supply with a relatively high voltage and a relatively strong output current capability. In contrast, the second input power supply should be connected to a power supply with a relatively low voltage and a relatively weak output current capability.

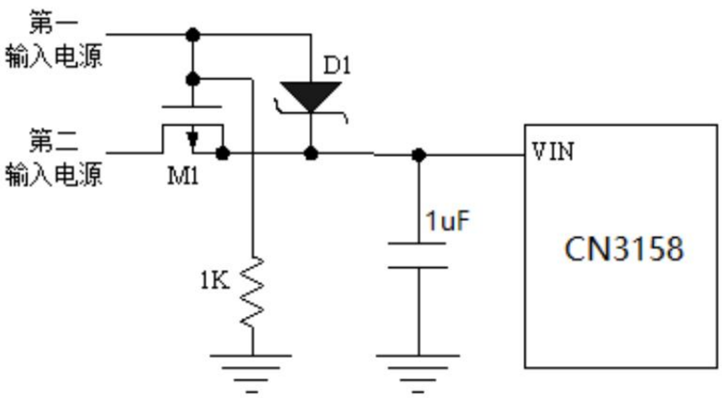



Figure 6 Using two input power sources to charge lithium batteries simultaneously

Battery temperature

monitoring To prevent the battery from being damaged by over-high or under-high temperature, CN3158 has an internal battery temperature monitoring circuit. Battery temperature monitoring is achieved by measuring the voltage of the TEMP pin, which is achieved by the NTC thermistor in the battery and a resistor divider network, as shown in Figure 7 by resistors R1 and R2.

CN3158 compares the voltage of TEMP pin with two internal thresholds VLOW and VHIGH to confirm whether the battery temperature is beyond the normal range. In CN3158, VLOW is fixed at 45%×VIN and VHIGH is fixed at 80%×VIN. If the voltage VTEMP of TEMP pin is <VLOW or VTEMP>VHIGH, it means that the battery temperature is too high or too low, and the charging process will be suspended; if the voltage VTEMP of TEMP pin is between VLOW and VHIGH , the charging cycle will continue. If the TEMP pin is connected to ground, the battery temperature monitoring function will be disabled.

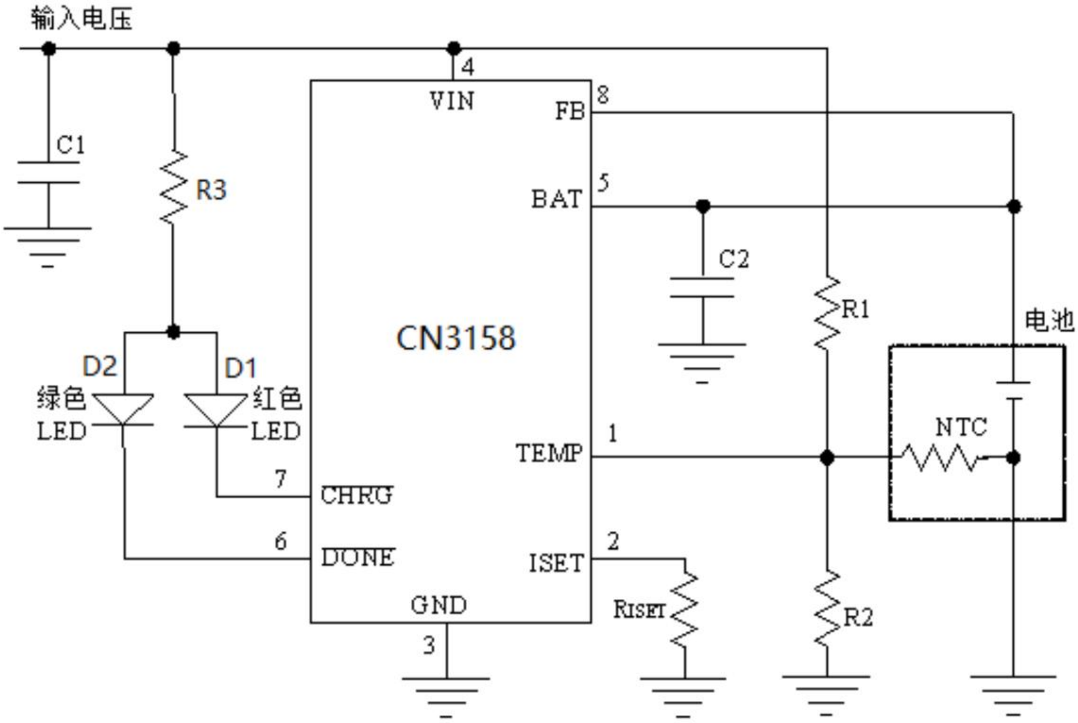



Figure 7 Using the battery temperature monitoring function

Determine the values of R1 and R2

In the circuit shown in Figure 7, the values of R1 and R2 must be determined based on the battery temperature monitoring range and the resistance value of the thermistor. described as follows:

Assume that the battery temperature range is set to TLÿTH (where TLÿTH); the battery uses a negative temperature coefficient thermistor (NTC). RTL is the resistance value at temperature TL , RTH is the resistance value at temperature TH , then RTLÿRTH, then at temperature TL , the first The voltage at the TEMP pin is:

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

At temperature TH , the voltage at the first pin TEMP is:

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

Then, VTEMPLÿVHIGHÿk2×VIN (k2=0.8)

VTEMPHÿVLOWÿk1×VIN (k1=0.45)

Then we can solve:

$$R1 = \frac{R_{TL}R_{TH}(k_2 - k_1)}{(R_{TL} - R_{TH})k_1 k_2}$$

$$R2 = \frac{R_{TL}R_{TH}(k_2 - k_1)}{R_{TL}(k_1 - k_1 k_2) - R_{TH}(k_2 - k_1 k_2)}$$

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

$$R1 = \frac{R_{TL}R_{TH}(k_2 - k_1)}{(R_{TH} - R_{TL})k_1 k_2}$$

R2ÿ RR (kk) TL TH 2 1
R (kk) TH 1 (kk) 1 2 TL 2 1 2

From the above derivation, it can be seen that the temperature range to be set has nothing to do with the power supply voltage VIN, but only with R1, R2, RTH, RTL Relevant; among them, RTH and RTL can be obtained by referring to relevant battery manuals or through experimental tests.

In practical applications, if you only care about the temperature characteristics of one end, such as overheat protection, R2 can be omitted and only R1 can be used. The derivation of becomes very simple and will not be repeated here.

## Recharge

When a charging cycle ends, if the charging current rises above the recharge threshold, CN3158 automatically starts a new charging cycle.

**Constant current/constant voltage/constant temperature charging**

CN3158 uses constant current/constant voltage/constant temperature mode to charge the battery, as shown in Figure 3. In constant current mode, the charging current is 1188V/RISET. The power consumption of CN3158 is too large, and the junction temperature of the device is close to 130ÿ. The amplifier Tamp starts to work and automatically adjusts the charging current to make the junction temperature of the device Maintain at approximately 130°C.

## Open drain status indication output

CN3158 has two open-drain status indication terminals, $\overline{CHRG}$ and $\overline{DONE}$, which can drive light-emitting diodes or microcontroller terminals. $\overline{CHRG}$ It is used to indicate the charging status. When charging, it is low level. $\overline{CHRG}$ It is used to indicate the charging end status. $\overline{DONE}$ When charging is finished, $\overline{DONE}$ When the battery temperature is outside the normal temperature range, both the $\overline{CHRG}$ and $\overline{DONE}$ pins output high impedance. When the battery is not connected to the charger, CN3158 charges the output capacitor to the constant voltage charging voltage and enters the charging end state. The $\overline{CHRG}$ pin output High impedance state, $\overline{DONE}$ low level.

The following table lists the two status indicator terminals and their corresponding charger status. Assuming the $\overline{CHRG}$ pin is connected to a red LED, $\overline{DONE}$ Pin connected to green LED

| $\overline{CHRG}$ the pin level (corresponding LED status) is low level | $\overline{DONE}$ Pin level (corresponding LED status) High impedance | status description |
|---|---|---|
| (the red LED is always on) and high | (green LED off) Low level (green LED | Charging |
| impedance (the red LED is off). | always on) | Charging end status |
| High impedance state (red LED off) | High impedance state (green LED off) | Three possible abnormal states:<br>ÿ Input voltage is lower than the power supply low voltage latch threshold, or<br>ÿ The input voltage is lower than the battery connection terminal BAT voltage, or<br>ÿ Abnormal battery temperature |

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

## Power input VIN bypass capacitor CIN

The power input terminal requires a filter capacitor (C1 in Figure 1 and Figure 2). Generally, a 1uF capacitor can meet the requirements. There are special requirements. If the output resistance of the adapter is relatively large or the connection line is relatively long, the capacitance value can be appropriately increased. When using ceramic capacitors, due to the resonance and high quality factor characteristics, a transient high voltage will be generated at the power input terminal of CN3158 when plugging or unplugging them. The chip may be damaged. In this case, the input power can be applied to CN3158 through a diode, as shown in the circuit in Figure 8 (diode D1), or add a TVS diode between the input and ground to suppress the overshoot voltage.

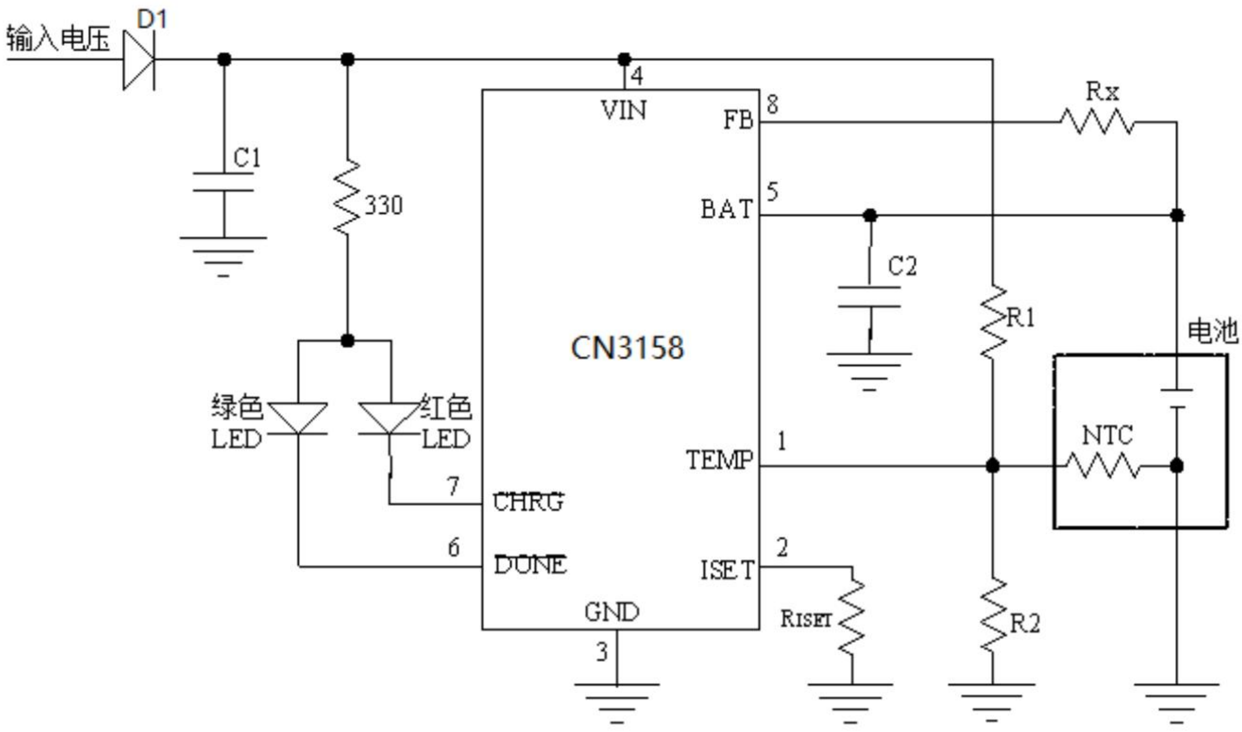



Figure 8 Adding a diode to suppress overshoot voltage

For considerations on input filter capacitors, please refer to our application note "AN102 Problems that may be caused by input power filter capacitors".

The Internet link address is "http://www.consonance-elec.com/pdf/Problems that may be caused by input power filter capacitors.pdf".

stability

In order to ensure the normal operation of CN3158, a capacitor with a capacitance of 1uF needs to be connected from the battery terminal BAT to GND.

In constant current mode, the resistor and capacitor connected to the ISET pin will also affect the stability of the system.

If there is an external capacitor at the ISET pin, an external resistor with a resistance value of up to 50K can be connected to this pin.

The resistance value will decrease. In order for the charger to work properly, the pole formed by the external resistor and capacitor on the ISET pin should be higher than 200KHz.

Assume that the ISET pin is connected to an external capacitor C. The following formula can be used to calculate the maximum external resistance value allowed for the ISET pin:

RISET < 1/(6.28×2×105 ×C)

PCB Design Considerations

(1) The charging current setting resistor of pin 2 ISET should be as close to CN3158 as possible, and the parasitic

The capacitor should be as small as possible.

(2) The filter capacitor of pin 4 VIN and the output filter capacitor of pin 5 BAT should be as close to CN3158 as possible. (3) During charging, the

temperature of CN3158 may be relatively high, so the NTC resistor of the battery should be as far away from CN3158 as possible. Otherwise,

The change of NTC resistance value cannot properly reflect the temperature of the battery.

(4) A PCB with good heat dissipation performance is critical to outputting the maximum charging current. The heat generated by the integrated circuit is transferred through the metal of the package.

The lead frame pins are spread out, and the copper layer on the PCB acts as a heat sink, so each pin (especially the GND pin)

The copper layer area should be as large as possible, and more through holes can also improve the heat handling capacity.

The power source will also affect the output current of the charger, and it should be fully considered when making the system

layout. In order to output the maximum charging current, it is required to solder the exposed metal plate on the back of CN3158 to the ground terminal of the printed circuit board.

Otherwise, the thermal resistance of the chip will increase, resulting in a decrease in charging current.

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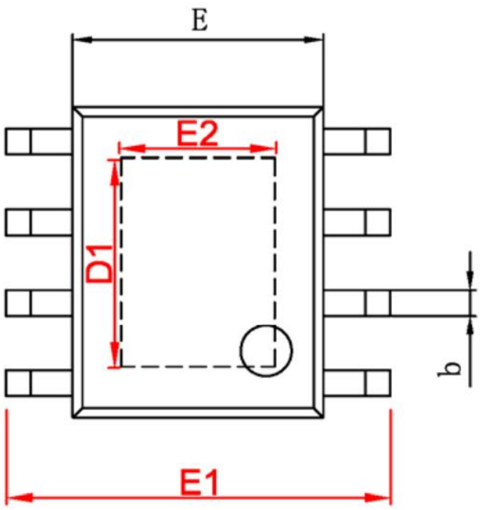
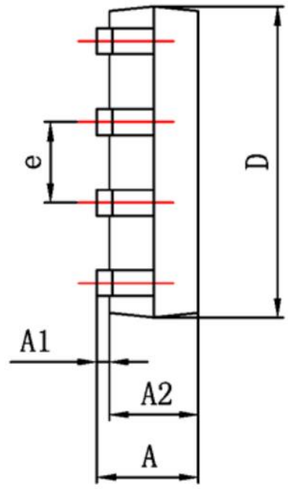
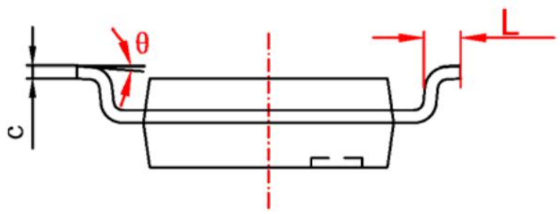
Packaging information




| 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° |