Multi-Chemistry Battery Charger for Solar-Powered Systems

CN3082

General Description:

CN3082 is a mutli-chemistry battery charge control chips for single cell lithium batteries, lithium iron phosphate and single or two to four nickel-metal hydride batteries. The device contains an on-chip power MOSFET and eliminates the need for the external sense resistor and blocking diode. CN3082 is specifically designed to work within USB power specifications. Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature. Chip integrates a high-precision voltage comparator, with 1% accuracy, you can accurately set the constant current charge termination voltage. An on-chip 8-bit ADC can adjust charging current automatically based on the output capability of input power supply, so CN3082 is ideally suited for solar powered system.

The charge current can be programmed externally with a single resistor. When the input supply is removed, the CN3082 automatically enters a low power sleep mode , dropping the battery drain current to less than 3uA. Other features include undervoltage lockout, automatic recharge, battery temperature sensing and charging/termination indicator.

The CN3082 is available in 8-pin SOP8 package.

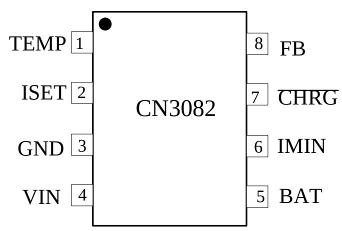
Applications:

- Cell Phone
- Digital Camera
- Electronic Dictionary
- Portable Devices
- The need for lithium batteries, nickel metal hydride batteries, lithium iron phosphate and lead-acid battery charging

Features:

- Suitable for the USB port or AC adapter
- On-chip Power MOSFET
- Constant current charge voltage accuracy of 1%
- On-chip 8-bit ADC can adjust charging current automatically based on the output capability of input power supply
- Suitable for Solar-Powered System
- Precharge Conditioning for Reviving Deeply Discharged Cells and Minimizing Heat Dissipation During Initial Stage of Charge
- Continuous Programmable Charge Current Up to 1000mA
- Constant-Current/Constant-Temperature Operation with Thermal Regulation to Maximize Charge Rate Without Risk of Overheating
- Automatic Low-Power Sleep Mode When Input Supply Voltage is Removed
- Status Indication LED drive or MCU interface
- Automatic Recharge
- Battery Temperature Sensing
- Available in SOP-8 Package
- Pb-free Available

Pin Assignment



Typical Application Circuit

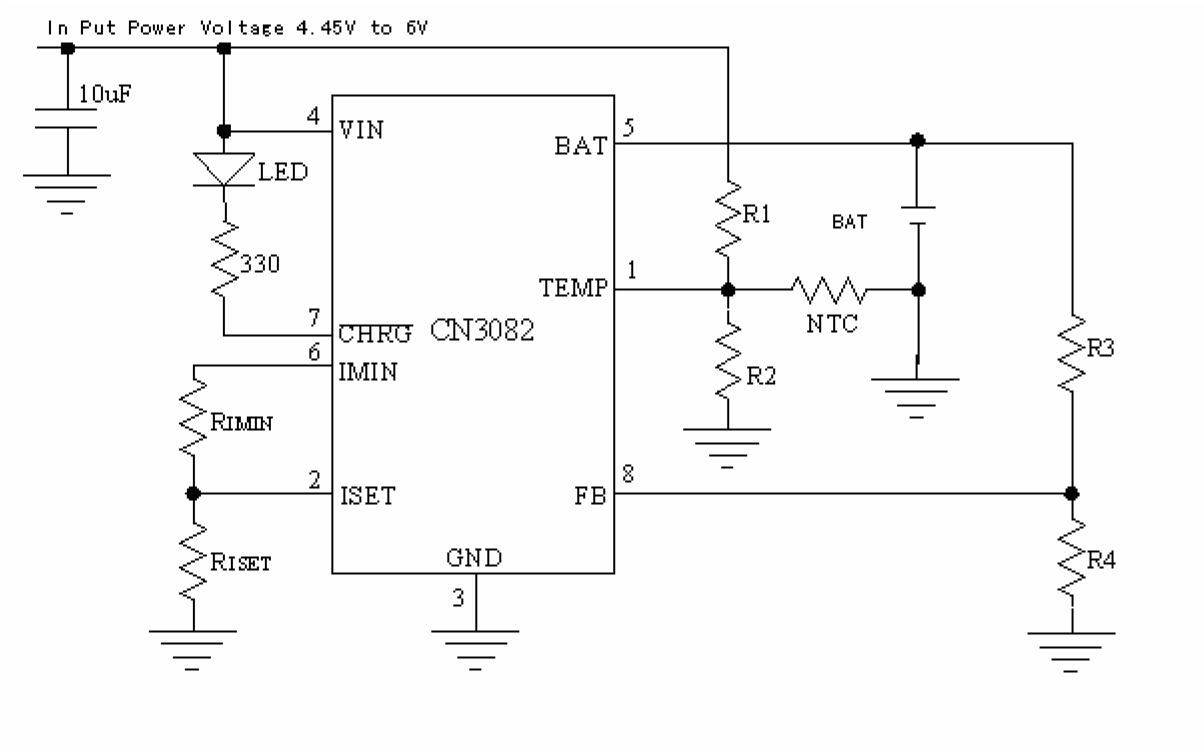


Figure 1 Typical Application Circuit

Ordering Information

Part Number	Package	Operating Ambient Temperature	Package
CN3082	SOP8	－40℃ 到 85℃	Panel Mount, 2500 / disc

Block Diagram

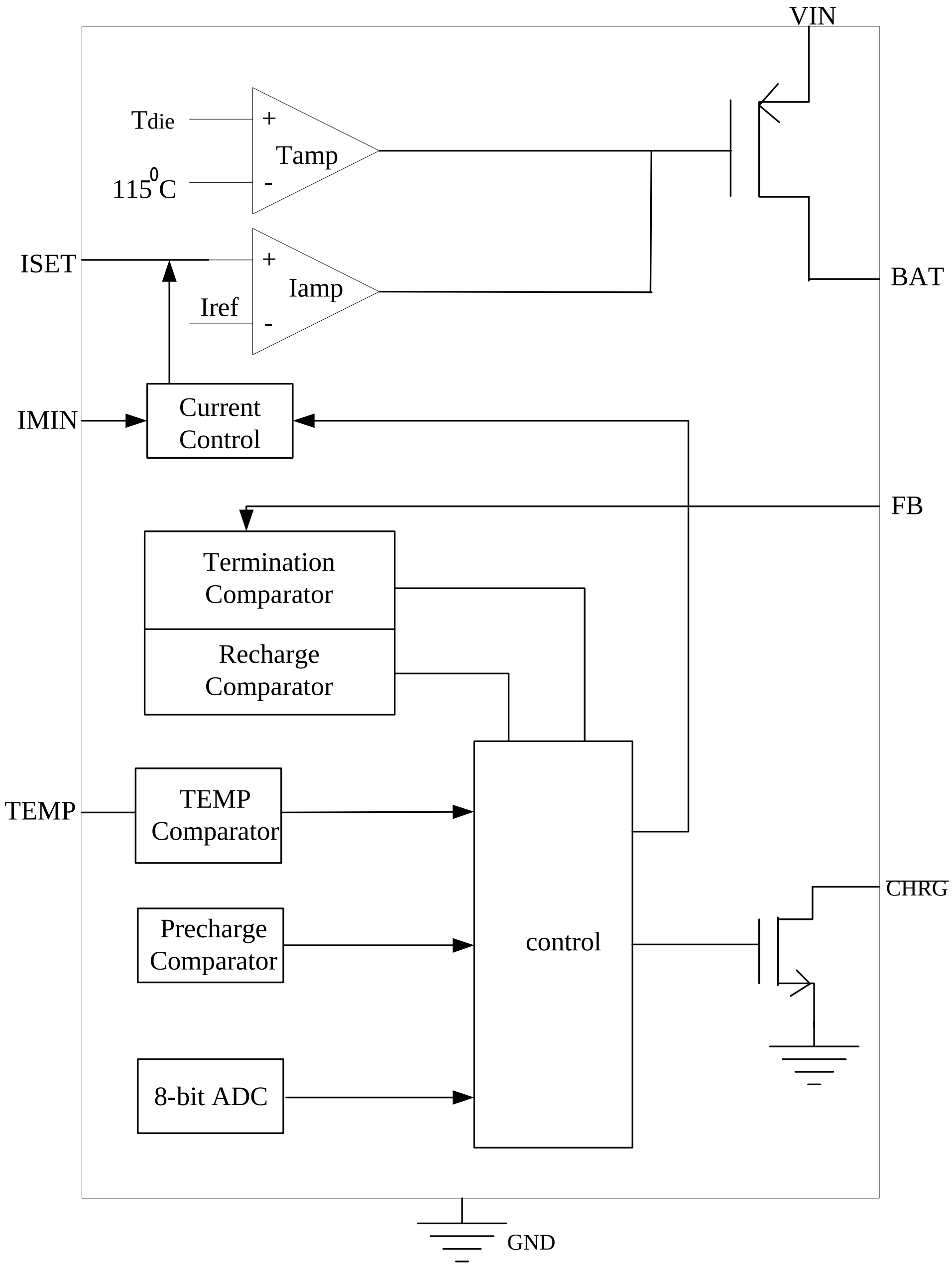


Figure 2 Block Diagram

Pin Description

Pin No.	Name	Function Description
1	TEMP	**Temperature Sense Input.** Connecting TEMP pin to NTC thermistor's output in Lithium ion battery pack. If TEMP pin's voltage is below 45% or above 80% of supply voltage V_{IN} for more than 0.15S, this means that battery's temperature is too high or too low, charging is suspended. If TEMP's voltage level is between 45% and 80%of supply voltage for more than 0.15S, battery fault state is released, and charging will resume. The temperature sense function can be disabled by grounding the TEMP pin.
2	ISET	**Constant Charge Current Setting and Charge Current Monitor Pin.** The charge current is set by connecting a resistor R_{ISET} from this pin to GND. When in precharge and Continuous charge mode, the ISET pin's voltage is regulated to 0.44V. When in constant charge current mode, the ISET pin's voltage is regulated to 2.2V. The constant current is determined by: $I_{CH} = 1950V / R_{ISET}$ (A) In the pre-charge mode, the charge current is 20% of the constant charging current.
3	GND	**Ground Terminal.**
4	VIN	**Positive Input Supply Voltage.** VIN is the power supply to the internal circuit. When VIN drops to within 40mv of the BAT pin voltage, CN3082 enters low power sleep mode, dropping BAT pin's current to less than 3uA.
5	BAT	**Battery Connection Pin.** Connect the positive terminal of the battery to BAT pin. BAT pin draws less than 3uA current in chip disable mode or in sleep mode. BAT pin provides charge current to the battery.
6	IMIN	**Set the Continuous current.** In the constant current charge mode, when the battery voltage reaches the set charge termination voltage, constant current charging mode ends, CN3082 access to continuous charge mode, and to continuous the current to charge the battery, but as long as the input voltage, CN3082 would have been to continuous the current to the battery. Continuous the current is determined by: $I_{MIN} = (0.44 / R_{ISET} + 0.44 / R_{IMIN} - VIN / R_{IMIN}) \times 886$ If the type is negative, it means that Continuous the current is 0 . Therefore, to continuous the current range can be set from 0 to constant charging current of 20%.
7	$\overline{CHRG}$	**Open Drain Charge Status Output.** When CN3082 is the pre-charging and constant current charging mode, $\overline{CHRG}$ pin is pulled low by an internal switch, otherwise $\overline{CHRG}$ pin is in high impedance state.
8	FB	**Battery voltage feedback input.** Battery voltage through this pin back to the CN3082. When the FB pin voltage is less than 1.54V ,CN3082 in a precharge mode; When the FB pin voltage is greater than 1.54V and less than 2.445V, CN3082 in a constant charge mode;When the FB pin voltage up to 2.445V , CN3082 end of the constant current charge mode, access to the Continuous charge

		mode. So the battery terminal voltage: V_{BAT}＝2.445×（1＋R3 / R4） Note: When the FB pin in hand soldering, welding time is shorter, so that this pin to Continuous a lower temperature.

Absolute Maximum Ratings

All Terminal Voltage……………－0.3V to 6.5V
BAT Short-Circuit Duration………..Continuous
Storage Temperature…............－65℃ to 150℃
Maximum Junction Temperature…...150℃
Operating Temperature…...－40℃ to 85℃
Lead Temperature(10s)……............260℃

Stresses beyond those listed under 'Absolute Maximum Ratings' may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to Absolute Maximum Rating Conditions for extended periods may affect device reliability.

Electrical Characteristics

(VIN=5V, TA=－40℃ to 85℃, Typical Values are measured at TA=25℃,unless otherwise noted))

Parameters	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Supply Voltage	VIN		4.45		6	V
Operating Current	I_{VIN}	Charge Termination Mode	400	650	950	uA
Undervoltage Lockout	Vuvlo	VIN falling		3.75	4	V
Undervoltage Lockout Hysteresis	Huvlo			0.1		V
BAT pin Current	I_{BAT}	R_{ISET}＝3.9K，constant current mode	400	500	600	mA
		R_{ISET}＝3.9K，V_{FB}＝0V	25	50	75	mA
		V_{IN}=0V，sleep mode			3	uA
FB Pin						
Precharge Threshold	V_{PRE}	V_{FB} rising	1.08	1.54	1.6	V
Precharge Threshold Hysteresis	H_{PRE}			0.1		V
Constant Current Charge Termination Threshold	Vterm	V_{FB} rising	2.42	2.445	2.47	V
Recharge Threshold	V_{RECH}	V_{FB} falling	1.6	1.65	1.7	V
Sleep Mode						
Sleep Mode Threshold	V_{SLP}	V_{IN} from high to low, measures the voltage (V_{IN}－V_{BAT})		40		mv
Sleep mode Release Threshold	V_{SLPR}	V_{IN} from low to high, measures the voltage (V_{IN}－V_{BAT})		90		mv
ISET Pin						
ISET Pin Voltage	V_{ISET}	VFB<1.54V or VFB>2.445V		0.44		V
		1.54<VFB<2.445V		2.2		V
TEMP管脚						
High Input Threshold	VHIGH	The voltage at TEMP increases	77.5	80	82.5	$\%V_{IN}$
Low Input Threshold	VLOW	The voltage at TEMP decreases	42.5	45	47.5	$\%V_{IN}$

TEMP input Current		TEMP to V_{IN} or to GND	0.5	uA
$\overline{CHRG}$ Pin				
$\overline{CHRG}$ Sink Current	I_{CHRG}	V_{CHRG}＝0.3V，charge status	10	mA
$\overline{CHRG}$ Leakage Current		VIN＝0V，V_{CHRG}＝6V	1	uA

Detailed Description

CN3082 is a mutli-chemistry battery charge control chips for single cell lithium batteries, lithium iron phosphate and single or two to four nickel-metal hydride batteries. The device contains an on-chip power MOSFET and eliminates the need for the external sense resistor and blocking diode. CN3082 is specifically designed to work within USB power specifications. Continuous charge current can be programmed up to 600mA with an external resistor.

The on-chip 8-bit ADC can adjust charging current automatically based on the output capability of input power supply, so CN3082 is ideally suited for the solar-powered systems, or the applications that need to charge battery with an input power supply whose output capability is limited.

The internal thermal regulation circuit reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 115℃. This feature protects the CN3082 from excessive temperature, and allows the user to push the limits of the power handling capability of a given circuit board without risk of damaging the CN3082 or the external components. Another benefit of adopting thermal regulation is that charge current can be set according to typical, not worst-case, ambient temperatures for a given application with the assurance that the charger will automatically reduce the current in worst-case conditions.

The charge cycle begins when the voltage at the VIN pin rises above the UVLO level, The $\overline{CHRG}$ pin outputs a logic low to indicate that the charge cycle is in precharge or constant current charge mode. At the beginning of the charge cycle, if the voltage at FB pin is below 1.54V, the charger is in precharge mode and charging current is set by constant current of 20% .The charger goes into the fast charge constant current mode once the voltage on the FB pin rises above 1.54V and below 2.445V. In constant current mode, the charge current is set by R_{ISET}. CN3082 goes into the Continuous charge mode once the voltage on the FB pin rises above 2.445V, the maintain charging current is determined by the input voltage VIN, RISET and RIMIN(as finger 1),. $\overline{CHRG}$ pin assumes a high impedance state. In maintaining charge mode, when the battery voltage feedback input FB pin voltage drops to 1.65V, CN3082 will begin a new charge cycle, into the pre-charge mode or constant-current charging mode. Of course, the input voltage can also be off, then power on to start a new charge cycle. On-chip precision voltage reference and comparator circuit to ensure constant current charge voltage accuracy within 1%, to meet a variety of rechargeable batteries. When the input voltage is not present, the charger goes into a sleep mode, dropping battery drain current to less than 3uA. This greatly reduces the current drain on the battery and increases the standby time. The charging process shown in Figure 3:

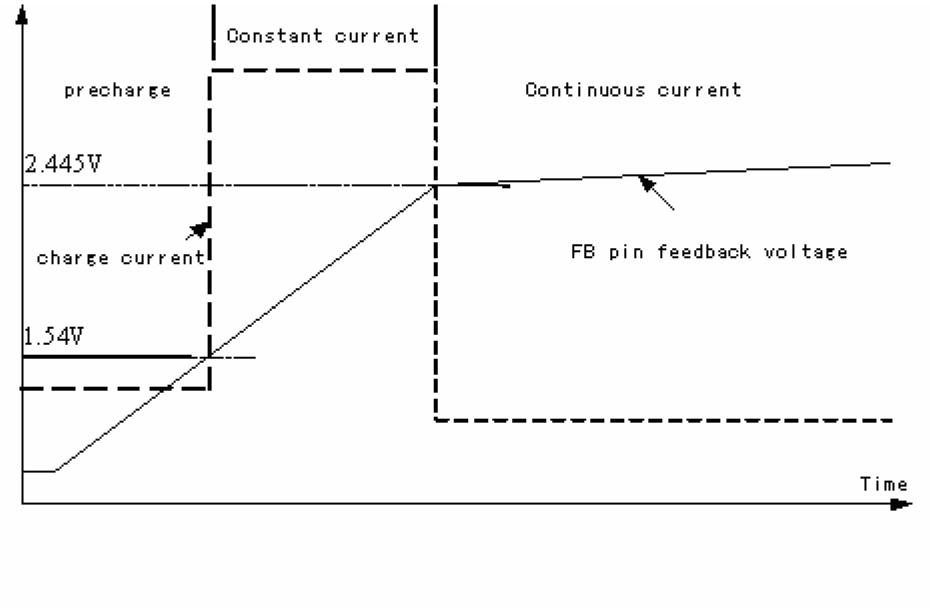


Figure 4 Charging Profile

Application Information

Undervoltage Lockout (UVLO)

CN3082 has an internal undervoltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until V_{IN} rises above the undervoltage lockout voltage.

Sleep mode

There is an on-chip sleep comparator in CN3082. The comparator keeps the charger in sleep mode if V_{IN} falls below sleep mode threshold(VBAT+20mv). Once in sleep mode, the charger will not come out of sleep mode until V_{IN} rises 90mv above the battery voltage.

Charging Current limited by the Output capability of Input Power Supply

If the output capability of input power supply is less than the charging current set by the resistor at ISET pin, then the on-chip 8-bit ADC will begin to function to adjust the charging current based on the output capability of input power supply. In this case, the charging current may be less than the value set by the resistor at ISET pin, but it is maximized to the output capability of input power supply. So the charging current can be set according to the maximum output capability of input power supply, not the worst case.. Therefore , it is very suitable for the use of solar panels and other current limited output voltage of a battery charging applications.

Precharge mode

If the battery voltage feedback input FB pin voltage falls below 1.54V, CN3082 goes into precharge mode , and the charge current is 20% of fast charge current in constant current mode.

Constant Current charge state

If the battery voltage feedback input FB pin voltage greater than 1.54V, and less than 2.445V, the CN3082 is in constant current charge status. In the constant current charging stage, charge current calculation formula is:

$$I_{CH} = 1950V / R_{ISET}$$

Which, I_{CH} is the charge current in amps

RISET is the ISET pin to ground resistance in ohms

For example, if you need 500 mA charge current, according to the following formula:

$$R_{ISET} = 1950V/0.5A = 3.9k\Omega$$

For best stability over temperature and time, 1% metal film resistors are recommended.

Continuous charge state

If the battery voltage feedback input FB pin voltage is greater than 2.445V, the CN3082 is to the continuous charging mode.

In the continuous charging mode, the battery charge current formula is:

$$I_{MIN} = (0.44 / R_{ISET} + 0.44 / R_{IMIN} - VIN / R_{IMIN}) \times 886$$

Which, I_{MIN} is charging current to continuous charge mode, in amperes

RISET is the ISET pin to ground resistance in ohms

RIMIN is resistance to connect ISET pin with IMIN pin in ohms

If the type is negative, it means continuous current is 0 amps， so the continuous current range can be set from 0 Amps to constant charging current of 20%. In practice, this method will be maintained by the charging current is set to 0 amps.

The continuous charging current is mainly used to make up the battery self-discharge effect and the load on the battery power consumption, etc., to ensure that the battery has been in a full state. As long as the input voltage is greater than the battery voltage, the continuous charge current has been existed. Therefore, to set the charge current when the battery should be based on the types, characteristics and use of electricity load should be set to decide whether to keep current and continue the current size. Technical specifications of the book in the battery will indicate whether to allow continued to charge the battery, and can withstand continuous charge current. In the application, set the charge current should not exceed the maintenance of the battery can withstand this kind of continuous charge current, otherwise it will affect battery life.

The battery terminal voltage of constant current charging

Battery terminal voltage by R3 and R4 constitute a feedback resistor divider network to the FB pin, CN3082 FB pin voltage is decided according to the state of charge, as shown in Figure 1。When the FB pin voltage up to 2.445V, the charger end of the constant current charge status, access to continuous charge mode, the battery end of the corresponding constant current charge termination voltage:

$$V_{BAT} = 2.445 \times (1 + R3 / R4)$$

Therefore, constant-current charge termination voltage is a very important design parameter, which determines the fast charge termination voltage, constant current charge also determines the full extent after the end of the battery.

In the design of constant current charge termination voltage, mainly to consider the battery's internal resistance and the parasitic resistance of the connection charge effects. Any battery has internal resistance, but resistance values is different. Connect the battery positive and negative equivalent resistance of the wire also exist，as shown in Figure 4.

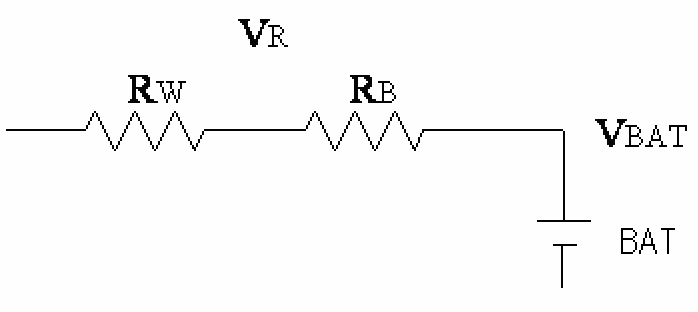


Figure 4 battery's internal resistance and parasitic resistance wire diagram

Which, R_B for the battery internal resistance, R_W equivalent resistance for the wire, the wire equivalent resistance, including resistance and the parasitic wire connector contact resistance and so on.

In the constant current charging stage, charge current flows through the resistor R_B and R_W, voltage drop V_R, Assuming that the true battery voltage V_{BAT}, then the CN3082 terminal detects the feedback voltage is VBAT + VR, does not accurately reflect the battery voltage. So when the constant current charging period after the end of the battery voltage has not reached the true set of values, may cause the battery is not too full.

Therefore, to set the termination voltage, should compensate the battery's internal resistance and the equivalent resistance of the wire for charging the battery as full. Compensation method is to phase in the constant current charging R_B and R_W on the voltage drop with the battery voltage as full charge voltage constant. That is, assuming full battery voltage V_{BAT}, the battery internal resistance and voltage drop on wire V_R, then the constant current charge termination voltage should be:

$$Vterm = V_{BAT} + V_R$$

Which, Vterm termination voltage to constant current charging

V_{BAT} is the battery voltage when fully charged

V_R is the voltage drop of the wire resistance and the equivalent resistance in the constant current charging.

In the application, it is no need to measure the battery's internal resistance and equivalent resistance wire, as long as a simple experiment you can know V_R. The first measurement of the battery open circuit voltage between the battery positive and negative; then access the battery charging circuit consisting of CN3082, CN3082 and to phase in the constant current charging, and then measure the CN3082's 5-pin to ground (GND) between the voltage, the voltage difference between two measurements is the battery internal resistance and constant current charging phase conductor voltage drop on the equivalent resistance.

Recharge

In continuous charge mode, when the battery voltage feedback input FB pin voltage drops to 1.65V , CN3082 will begin a new charge cycle, into the pre-charge modeconstant-current charging mode. The input voltage can also be off, then power on to start a new charge cycle.

Combine Two Power Inputs

Although the CN3082 allows charging from a USB port, a wall adapter can also be used to charge Li-Ion/Li-polymer batteries. Figure 5 shows an example of how to combine wall adapter and USB power inputs. A P-channel MOSFET, M1, is used to prevent back conducting into the USB port when a wall adapter is present and Schottky diode, D1, is used to prevent USB power loss through the 1kΩ pull-down resistor.

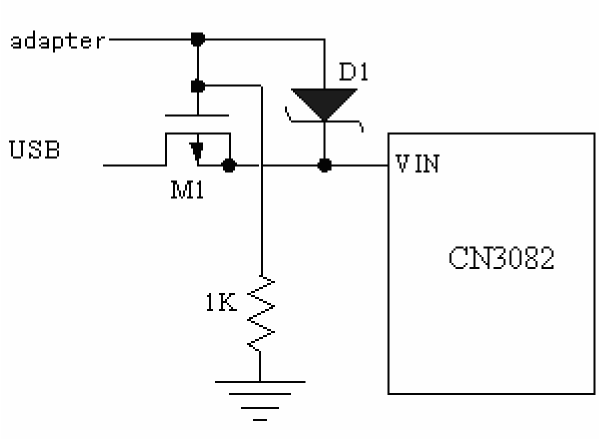


Figure 5 Combining Wall Adapter and USB interfaces

Battery Temperature Sense

To prevent the damage caused by the very high or very low temperature done to the battery pack, the CN3082 continuously senses battery pack temperature by measuring the voltage at TEMP pin determined by the voltage divider circuit and the battery's internal NTC thermistor as shown in Figure 1.

The CN3082 compares the voltage at TEMP pin (V_{TEMP}) against its internal V_{LOW} and V_{HIGH} thresholds to determine if charging is allowed. In CN3082, V_{LOW} is fixed at (45%×VIN), while V_{HIGH} is fixed at (80%×VIN). If $V_{TEMP}<V_{LOW}$ or $V_{TEMP}>V_{HIGH}$ for 0.15 seconds, it indicates that the battery temperature is too high or too low and the charge cycle is suspended. When V_{TEMP} is between V_{LOW} and V_{HIGH} for more than 0.15 seconds, the charge cycle resumes.

The battery temperature sense function can be disabled by connecting TEMP pin to GND.

Selecting R1 and R2

The values of R1 and R2 in the application circuit can be determined according to the assumed temperature monitor range and thermistor's values. The Follows is an example:

Assume temperature monitor range is TL～TH (TL＜TH); the thermistor in battery has negative temperature coefficient (NTC), RTL is thermistor's resistance at TL, RTH is the resistance at TH, so RTL＞RTH, then at temperature TL, the voltage at TEMP pin is:

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

At temperature TH, the voltage at TEMP pin is:

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

We know, $V_{TEMPL}=V_{HIGH}=k_2 \times VIN$ ($k_2=0.84$)

$V_{TEMPH}=V_{LOW}=k_1 \times VIN$ ($k_1=0.47$)

Then we can have:

$$R1 = \frac{R_{TL}R_{TH}(k_2-k_1)}{(R_{TL}-R_{TH})k_1k_2}$$

$$R2 = \frac{R_{TL}R_{TH}(k_2-k_1)}{R_{TL}(k_1-k_1k_2)-R_{TH}(k_2-k_1k_2)}$$

Likewise, for positive temperature coefficient thermistor in battery, we have RTH＞RTL and we can calculate:

$$R1 = \frac{R_{TL}R_{TH}(k_2-k_1)}{(R_{TH}-R_{TL})k_1k_2}$$

$$R2 = \frac{R_{TL}R_{TH}(k_2-k_1)}{R_{TH}(k_1-k_1k_2)-R_{TL}(k_2-k_1k_2)}$$

We can conclude that temperature monitor range is independent of power supply voltage VIN and it only depends on R1, R2, R_{TL} and R_{TH}: The values of R_{TH} and R_{TL}can be found in related battery handbook or deduced from testing data.

In actual application, if only one terminal temperature is concerned(normally protecting overheating), there is no need to use R2 but R1. In this case it becomes very simple to calculate R1.

Constant-Current/ Constant-Temperature

The CN3082 use a unique architecture to charge a battery in a constant-current, constant temperature fashion as shown in Figure 2. Whether in the pre-charge state or in the constant current charge state, or continuous charge state, if the CN3082's power dissipation of the device's junction temperature close to 115 ℃， amplifier Tamp begin to control the charging current, the device's junction temperature maintained at about 115 ℃.

Open-Drain Status Outputs

The CN3082 have an open-drain status outputs: $\overline{CHRG}$.$\overline{CHRG}$ is pulled low when the charger is in charging status, otherwise becomes high impedance (including battery temperature abnormality).

When not use charging status indicator function，connect $\overline{CHRG}$ pin to the ground.

VIN Bypass Capacitor CIN

Many types of capacitors can be used for input bypassing, C_{IN} is typically a 10uF capacitor.

For the consideration of the bypass capacitor, please refer to the Application Note AN102 from our website "http://www.consonance-elec.com/pdf/输入电源滤波电容可能引起的问题.pdf"。

Battery test

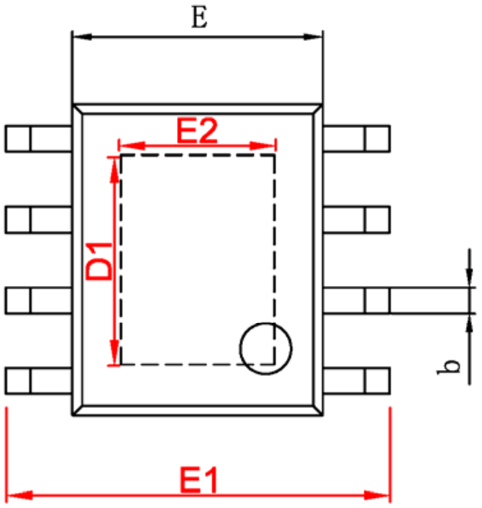
CN3082 has no internal battery detection circuit, when the battery is not connected, depending on the connected load BAT pin status，The BAT pin voltage may be charged to the above set of constant current charge termination voltage, and even close to the input voltage VIN, which is a normal phenomenon.

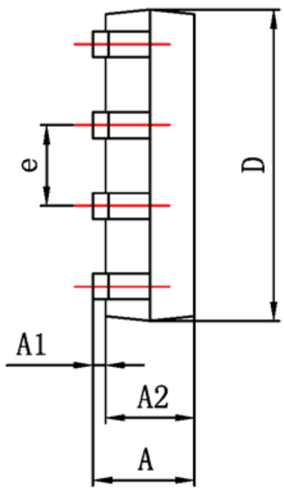
Under normal circumstances, it is best not to access the input voltage before and after insert a battery, because the moment the battery access, will produce instantaneous voltage surge, or BAT pin in between the battery and the contact resistance, which may affect the CN3082 battery voltage detection.

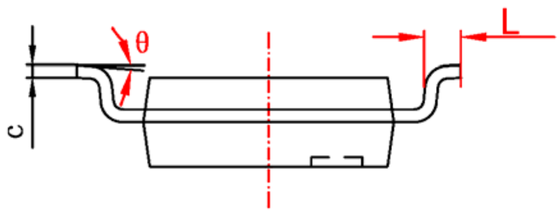
Board Layout Considerations

1. R_{ISET} at ISET pin should be as close to CN3082 as possible, also the parasitic capacitance at ISET pin should be kept as small as possible.
2. The capacitance at VIN pin and BAT pin should be as close to CN3082 as possible.
3. During charging, CN3082's temperature may be high, the NTC thermistor should be placed far enough to CN3082 so that the thermistor can reflect the battery's temperature correctly.
4. It is very important to use a good thermal PCB board layout to maximize charging current. The thermal path for the heat generated by the IC is from the die to the copper lead frame through the package lead(especially the ground lead) to the PCB board copper, the PCB board copper is the heat sink. The footprint copper pads should be as wide as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient. Feedthrough vias to inner or backside copper layers are also useful in improving the overall thermal performance of the charger. Other heat sources on the board, not related to the charger, must also be considered when designing a PCB board layout because they will affect overall temperature rise and the maximum charge current. The ability to deliver maximum charge current under all conditions require that the exposed metal pad on the back side of the CN3082 package be soldered to the PCB board ground. Failure to make the thermal contact between the exposed pad on the backside of the package and the copper board will result in larger thermal resistance.

Package 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°