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CONSONANCE

Lithium Ion Battery Charger for Solar-Powered Systems

CN3163

General Description:

The CN3163 is a complete constant-current /constant voltage linear charger for single cell Li-ion and Li Polymer batteries. The device contains an on-chip power MOSFET and eliminates the need for the external sense resistor and blocking diode. An on-chip adaptive cell can adjust charging current automatically based on the output capability of input power supply, so CN3163 is ideally suited for solar powered system. Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature. The regulation voltage is internally fixed at 4.2V with 1% accuracy, it can also be adjusted upwards with an external resistor. The charge current can be set externally with a single resistor. When the input supply is removed, the CN3163 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 CN3163 is available in a thermally enhanced 8-pin SOP package.

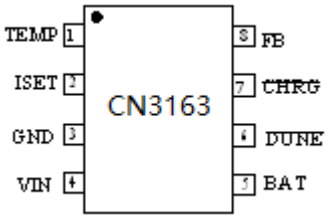
Applications:

- Solar Powered System
- Digital Still Cameras
- Bluetooth Applications
- Portable Devices
- Chargers

Features:

- Automatic charge current adjustment based on the output capability of input power supply
- Suitable for Solar-Powered System
- On-chip Power MOSFET
- No external Blocking Diode or Current Sense Resistors Required
- Preset 4.2V regulation voltage with 1% accuracy, upwards adjustable with a resistor
- Precharge Conditioning for Reviving Deeply Discharged Cells and Minimizing Heat Dissipation During Initial Stage of Charge
- Continuous Charge Current Up to 1A
- Constant-Current/Constant-Voltage 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 for LEDs or uP Interface
- C/10 Charge Termination
- Automatic Recharge
- Battery Temperature Sensing
- Available in eSOP8 Package
- Pb-free, rohs-Compliant and Halogen Free

Pin Assignment



Typical Application Circuit

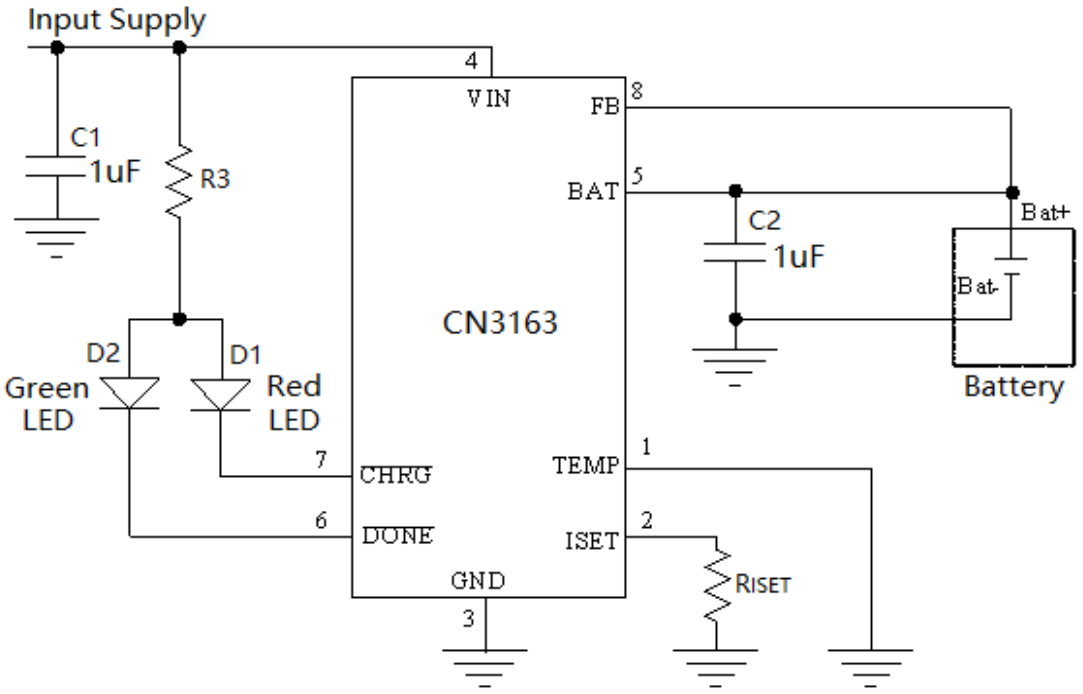


Figure 1 Typical Application Circuit(Constant Voltage Level 4.2V)

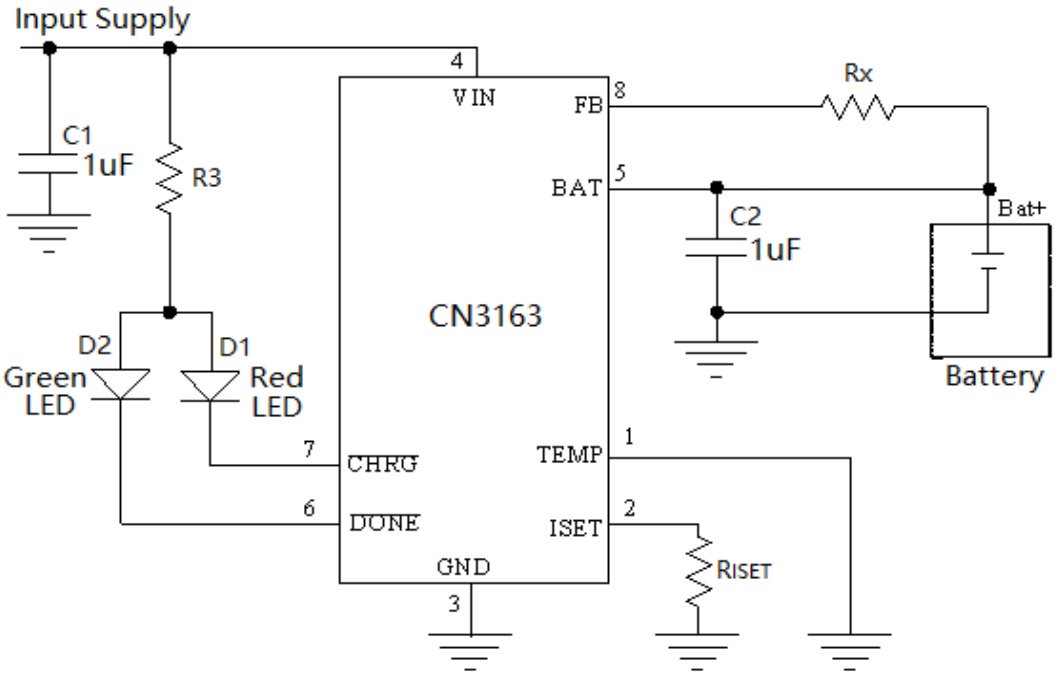


Figure 2 Application Circuit(Adjust Constant Voltage Level with Rx)

In Figure 2, the BAT pin's voltage in constant voltage mode is given by the following equation:

$$V_{REG} = 4.2 + 3.707 \times 10^{-6} \times Rx$$

Where, V_{REG} is in volt

Rx is in ohm

Ordering Information:

Part No.	Package	Shipping	Operating Temperature Range
CN3163	eSOP8	Tape and Reel, 4000/Reel	－40℃ to ＋85℃

Block Diagram

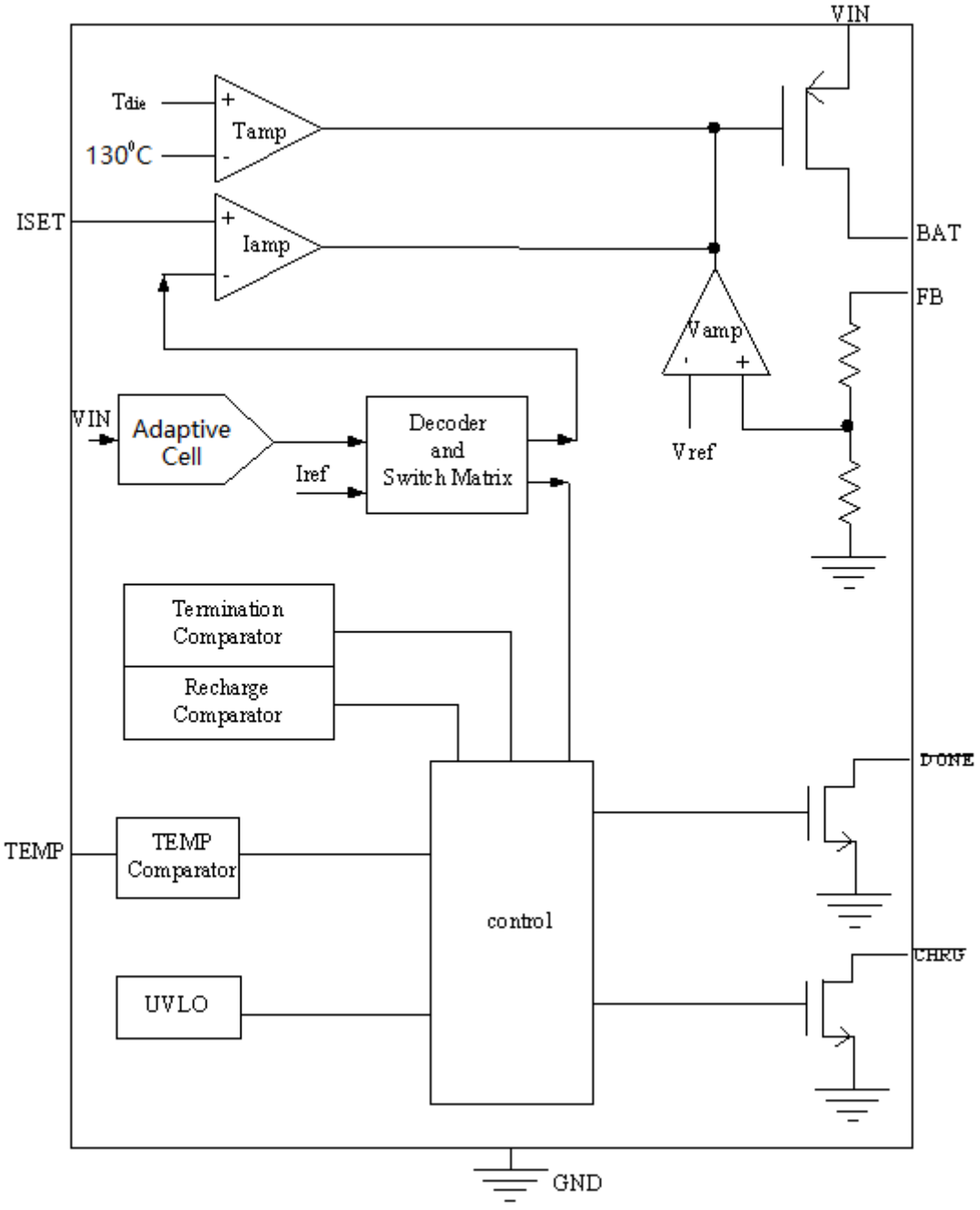


Figure 3 Block Diagram

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 VIN, 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, 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 mode, the ISET pin's voltage is regulated to 0.12V. When in constant charge current mode, the ISET pin's voltage is regulated to 1.205V. In all modes during charging, the voltage on ISET pin can be used to measure the charge current as follows: $I_{CH} = (V_{ISET} / R_{ISET}) \times 986$
3	GND	**Ground Terminal (Ground).**
4	VIN	**Positive Input Supply Voltage.** V_{IN} is the power supply to the internal circuit. When V_{IN} drops to within 10mv of the BAT pin voltage, CN3163 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 sleep mode. BAT pin provides charge current to the battery and provides regulation voltage.
6	$\overline{DONE}$	**Open-Drain Charge termination Status Output.** In charge termination status, $\overline{DONE}$ is pulled low by an internal switch; Otherwise $\overline{DONE}$ pin is in high impedance state.
7	$\overline{CHRG}$	**Open Drain Charge Status Output.** When the battery is being charged, the $\overline{CHRG}$ pin is pulled low by an internal switch, otherwise $\overline{CHRG}$ pin is in high impedance state.
8	FB	**Battery Voltage Sense Input.** This Pin can sense the battery voltage; Also the regulation voltage in constant voltage mode can be adjusted by connecting an external resistor between FB pin and BAT pin.

Absolute Maximum Ratings

All Terminal Voltage……－0.3V to 6.5V
BAT Short-Circuit Duration……...Continuous
Storage Temperature….....－65℃ to 150℃
Lead Temperature(Soldering, 10s)…….....260℃
Maximum Junction Temperature…...150℃
Operating Temperature…...－40℃ to 85℃
Thermal Resistance (SOP8)…….TBD

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, T_A=－40℃ to 85℃, Typical Values are measured at T_A=25℃,unless otherwise noted)

Parameters	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Supply Voltage	VIN		4.4		6	V
Operating Current	I_{VIN}	Charge Termination Mode	350	500	660	uA
Undervoltage Lockout	Vuvlo	VIN falling		2.4	2.65	V
Undervoltage Lockout Hysteresis	Huvlo			0.12		V
Soft Start Time	t_{SS}		100	160	220	uS
Regulation Voltage	V_{REG}	Constant Voltage Mode	4.158	4.2	4.242	V
BAT pin Current	I_{CC}	R_{ISET}=1.18K, V_{BAT}＝3.6V	900	1000	1100	mA
	I_{PRE}	R_{ISET}=1.18K, V_{BAT}＝2.4V	75	100	125	
	I_{SDBY}	V_{BAT}=V_{REG}, standby mode	1.8	3.7	7	uA
	I_{SLP}	VIN=0V, sleep mode			3	
Precharge Threshold						
Precharge Threshold	V_{PRE}	Voltage at BAT pin rising	67	70	73	%V_{REG}
Precharge Threshold Hysteresis	H_{PRE}			4.2		%V_{REG}
Charge Termination Threshold						
Charge Termination Threshold	Vterm	Measure voltage at ISET pin	96	120	144	mV
Recharge Threshold						
Recharge Threshold	I_{RECH}	Charge Current Rises		30%		%I_{CC}
Sleep Mode						
Sleep Mode Threshold	V_{SLP}	V_{IN} from high to low, measures the voltage (V_{IN}－V_{BAT})		10		mV
Sleep mode Release Threshold	V_{SLPR}	V_{IN} from low to high, measures the voltage (V_{IN}－V_{BAT})		60		mV
ISET Pin						
ISET Pin Voltage	V_{ISET}	Precharge mode		0.12		V
		Constant current mode		1.205		
TEMP PIN						
High Input Threshold	V_{HIGH}	The voltage at TEMP increases	77.5	80	82.5	%V_{IN}
Low Input Threshold	V_{LOW}	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
$\overline{DONE}$ **Pin**						
$\overline{DONE}$ Sink Current	I_{DONE}	V_{DONE}=0.3V, termination mode		10		mA
$\overline{DONE}$ Leakage Current		V_{DONE}=6V, charge mode			1	uA
$\overline{CHRG}$ **Pin**						
$\overline{CHRG}$ Sink Current	I_{CHRG}	V_{CHRG}=0.3V, Charge status		10		mA
$\overline{CHRG}$ Leakage Current		V_{CHRG}=6V, termination mode			1	uA

Detailed Description

The CN3163 is a linear battery charger IC designed primarily for charging single cell lithium-ion or lithium-polymer batteries. Featuring an internal P-channel power MOSFET, the charger uses a constant-current/constant-voltage to charge the batteries. Continuous charge current can be programmed up to 1A with an external resistor. No blocking diode or sense resistor is required. The on-chip adaptive cell can adjust charging current automatically based on the output capability of input power supply, so CN3163 is ideally suited for the solar-powered systems, or the applications that need to charge lithium-ion battery or lithium polymer battery with an input power supply whose output capability is limited. The open-drain output $\overline{DONE}$ and $\overline{CHRG}$ indicates the charger's status. The internal thermal regulation circuit reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 130℃. This feature protects the CN3163 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 CN3163 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, a current set resistor is connected from the ISET pin to ground. The $\overline{CHRG}$ pin outputs a logic low to indicate that the charge cycle is ongoing. At the beginning of the charge cycle, if the voltage at FB pin is below 70% of the regulation voltage, the charger is in precharge mode to bring the cell voltage up to a safe level for charging. The charger goes into the fast charge constant-current mode once the voltage on the FB pin rises above 70% of the regulation voltage. In constant current mode, the charge current is set by R_{ISET}. When the battery approaches the regulation voltage, the charge current begins to decrease as the CN3163 enters the constant-voltage mode. When the current drops to charge termination threshold, the charge cycle is terminated, $\overline{DONE}$ is pulled low by an internal switch and $\overline{CHRG}$ pin assumes a high impedance state to indicate that the charge cycle is terminated. The charge termination threshold is 10% of the current in constant current mode. To restart the charge cycle, just remove the input voltage and reapply it. The charge cycle can also be automatically restarted if the charge current rises the recharge threshold. The on-chip reference voltage, error amplifier and the resistor divider provide regulation voltage with 1% accuracy which can meet the requirement of lithium-ion and lithium polymer 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 profile is shown in the following figure:

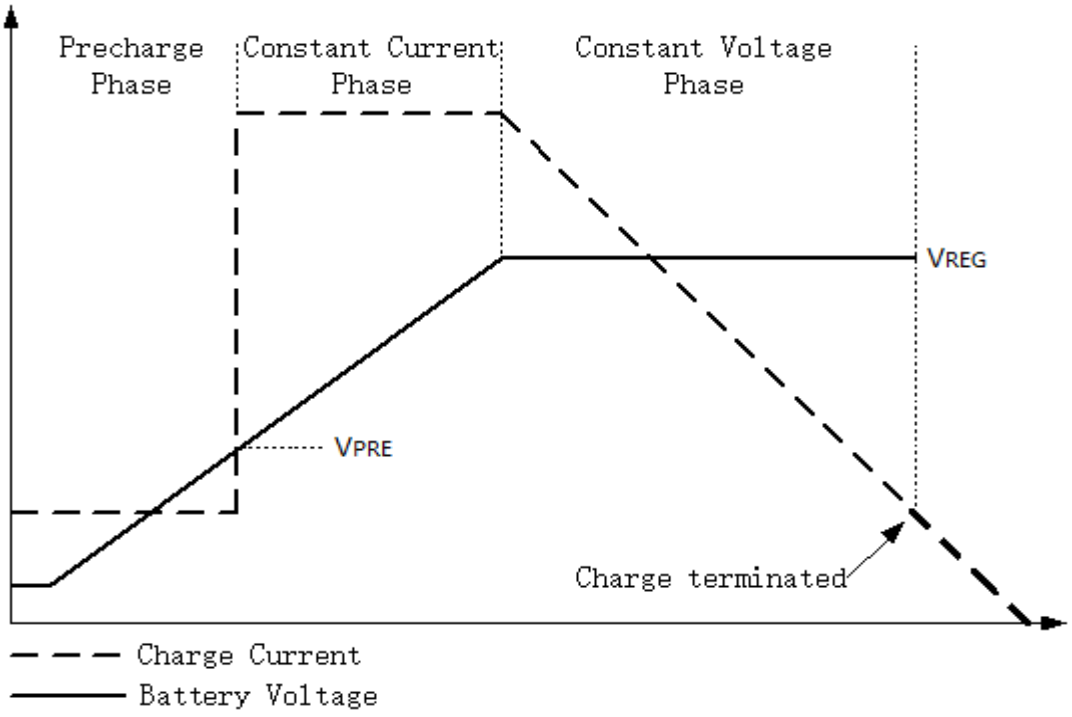


Figure 4 Charging Profile

Application Information

Undervoltage Lockout (UVLO)

An internal undervoltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until VIN rises above the undervoltage lockout voltage. The UVLO circuit has a built-in hysteresis of 0.12V.

Sleep mode

There is an on-chip sleep comparator. The comparator keeps the charger in sleep mode if VIN falls below sleep mode threshold(VBAT+10mv). Once in sleep mode, the charger will not come out of sleep mode until VIN rises 60mv above the battery voltage.

Precharge mode

At the beginning of a charge cycle, if the battery voltage is below 70% of the regulation voltage, the charger goes into precharge mode , and the charge current is 10% of fast charge current in constant current mode.

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 adaptive cell 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 on the condition that the input voltage at VIN pin is no less than 4.4V, which is the minimum operating voltage of CN3163. So the charging current can be set according to the maximum output capability of input power supply, not the worst case.

Adjusting the regulation voltage in constant voltage mode

The regulation voltage in constant voltage mode can be adjusted by an external resistor connecting between FB pin and BAT pin as shown in Figure 5:

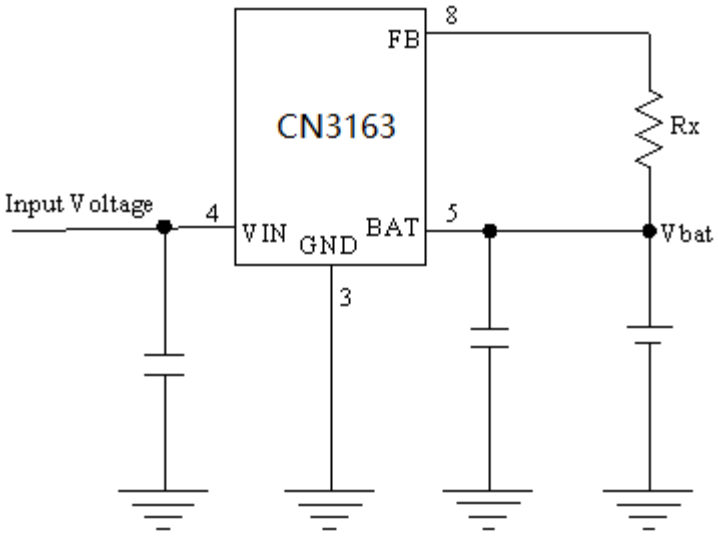


Figure 5 Adjusting Regulation Voltage in Constant Voltage Mode

In Figure 5, the regulation voltage in constant voltage mode will be given by the following equation:

$$V_{REG} = 4.2 + 3.707 \times 10^{-6} \times Rx$$

Where,

V_{REG} is in volt

Rx is in ohm

Setting Charge Current

The formula for the battery charge current in constant current mode is:

$$I_{CH} = 1188V / R_{ISET}$$

Where:

I_{CH} is the charge current in ampere

R_{ISET} is the total resistance from the ISET pin to ground in ohm

For example, if 1000mA charge current is required, calculate:

$$R_{ISET} = 1188V/1A = 1.18k\Omega$$

For best stability over temperature and time, 1% metal film resistors are recommended. If the charger is in constant-temperature or constant voltage mode, the charge current can be monitored by measuring the ISET pin voltage, and the charge current is calculated as the following equation:

$$I_{CH} = (V_{ISET} / R_{ISET}) \times 986$$

Combine Two Power Inputs

Although the CN3163 allows charging from a solar power supply, a wall adapter or a USB port can also be used to charge Li-Ion/Li-polymer batteries. Figure 6 shows an example of how to combine 2 power inputs. A P-channel MOSFET, M1, is used to prevent back conducting into the 2nd power supply when the 1st power supply is present and Schottky diode, D1, is used to prevent 2nd power supply loss through the 1kΩ pull-down resistor.

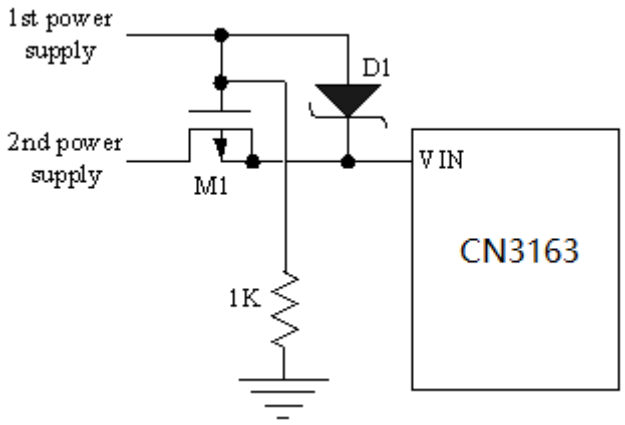


Figure 6 Combining 2 Input Power Supply

Battery Temperature Sense

To prevent the damage caused by the very high or very low temperature done to the battery pack, the CN3162 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 7.

The CN3162 compares the voltage at TEMP pin (V_{TEMP}) against its internal V_{LOW} and V_{HIGH} thresholds to determine if charging is allowed. In CN3162, V_{LOW} is fixed at (45%×VIN), while V_{HIGH} is fixed at (80%×VIN). If $V_{TEMP}<V_{LOW}$ or $V_{TEMP}>V_{HIGH}$, 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}, the charge cycle resumes.

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

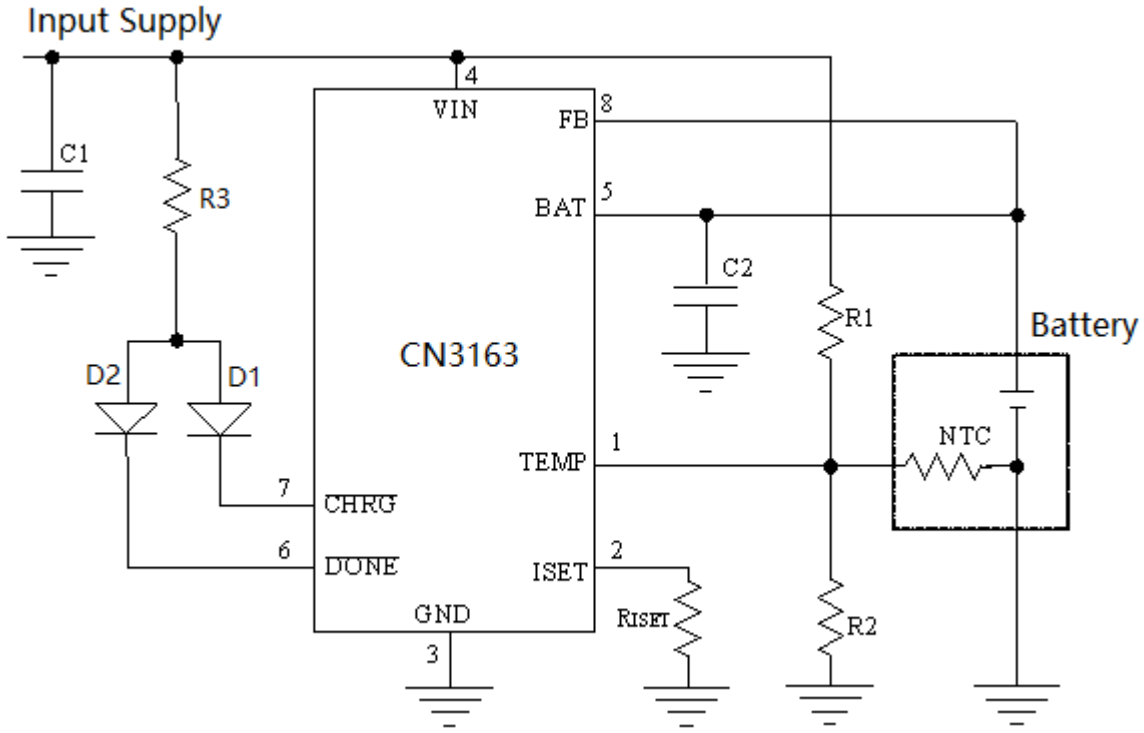


Figure 7 Monitoring Battery Temperature

Selecting R1 and R2

The values of R1 and R2 in Figure 7 can be determined according to the assumed temperature monitor range and thermistor's values. The Follows is an example:

Assume temperature monitor range is $T_L \sim T_H$ ($T_L < T_H =$; the thermistor in battery has negative temperature coefficient (NTC), R_{TL} is thermistor's resistance at T_L, R_{TH} is the resistance at T_H, so $R_{TL} > R_{TH}$, then at temperature T_L, the voltage at TEMP pin is:

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

At temperature T_H, 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=0.8)

$V_{TEMPH} = V_{LOW} = k_1 \times VIN$ (k_1=0.45)

Then we can have:

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

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

Likewise, for positive temperature coefficient thermistor in battery, we have $R_{TH} > R_{TL}$ and we can calculate:

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

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

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.

Recharge

After a charge cycle has terminated, if the charge current rises above 30% of the constant charge current, a new charge cycle will begin automatically.

Constant-Current/Constant-Voltage/Constant-Temperature

The CN3163 use a unique architecture to charge a battery in a constant-current, constant-voltage, constant temperature fashion as shown in Figure 3. Amplifiers Iamp, Vamp, and Tamp are used in three separate feedback loops to force the charger into constant-current, constant-voltage, or constant-temperature mode, respectively. In constant current mode the charge current delivered to the battery equal to $1188V/R_{ISET}$. If the power dissipation of the CN3163 results in the junction temperature approaching 130℃, the amplifier Tamp will begin decreasing the charge current to limit the die temperature to approximately 130℃. As the battery voltage rises, the CN3163 either returns to constant-current mode or it enters constant voltage mode straight from constant-temperature mode.

Open-Drain Status Outputs

The CN3163 have 2 open-drain status outputs: $\overline{DONE}$ and $\overline{CHRG}$. $\overline{CHRG}$ is pulled low when the charger is in charging status, otherwise $\overline{CHRG}$ becomes high impedance. $\overline{DONE}$ is pulled low if the charger is in charge termination status, otherwise $\overline{DONE}$ becomes high impedance.

The open drain status output that is not used should be tied to ground.

VIN Bypass Capacitor

Many types of capacitors can be used for input bypassing(C1 in Figure 1 and 2), Generally, a 1uF ceramic capacitor, placed in close proximity to VIN and GND pins, works well. In some applications depending on the power supply characteristics and cable length, it may be necessary to increase the capacitor's value.

If the ceramic capacitor is used as the input supply bypassing purpose, a voltage spike may be created when the input voltage is applied to the CN3163 via a cable. If the cable is a bit long, the circuit shown in Figure 6 or a TVS diode from VIN pin to GND should be considered to use to prevent the CN3163 from being damaged by the voltage spike.

For the consideration of the bypass capacitor, please refer to the Application Note AN102 from our website.

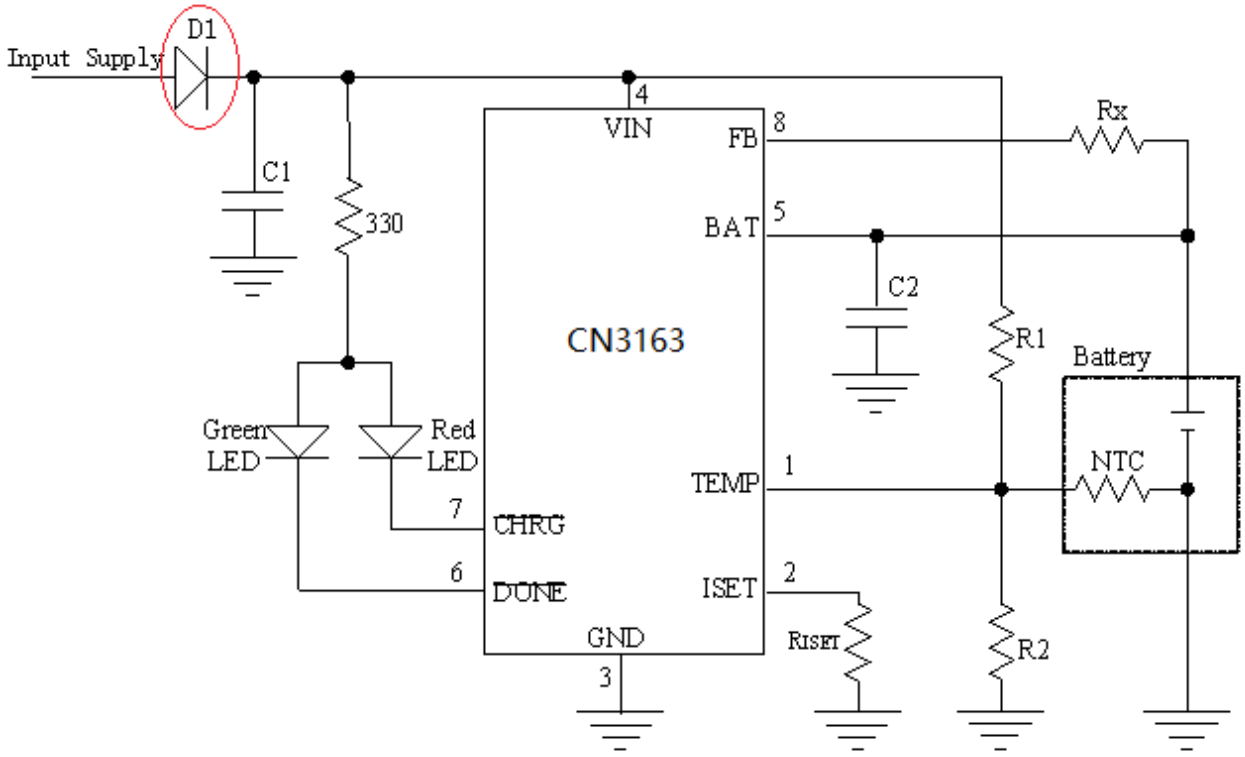


Figure 6 Adding Diode D1 to Suppress Voltage Spike

Stability

Typically a 1uF capacitor from BAT pin to GND is required to stabilize the feedback loop.

In constant current mode, the stability is also affected by the impedance at the ISET pin . With no additional capacitance on the ISET pin, the loop is stable with current set resistors values as high as 50KΩ. However, additional capacitance on ISET pin reduces the maximum allowed current set resistor. The pole frequency at ISET pin should be kept above 200KHz. Therefore, if ISET pin is loaded with a capacitance C, the following equation should be used to calculate the maximum resistance value for R_{ISET}:

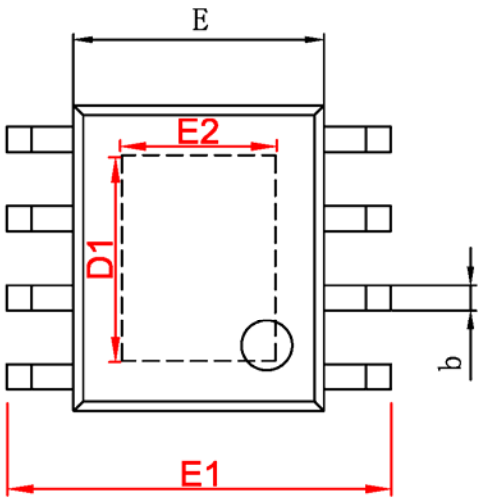
$$R_{ISET} < 1 / (6.28 \times 2 \times 10^5 \times C)$$

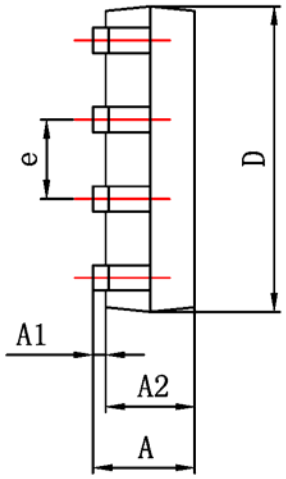
Board Layout Considerations

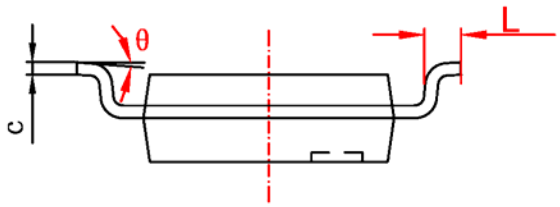
1. R_{ISET} at ISET pin should be as close to CN3163 as possible, also the parasitic capacitance at ISET pin should be kept as small as possible.
2. The capacitance at VIN pin and BAT pin should be as close to CN3163 as possible.
3. During charging, CN3163's temperature may be high, the NTC thermistor should be placed far enough to CN3163 so that the thermistor can reflect the battery's temperature correctly.
4. It is very important to use a good thermal PC 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 PC board copper, the PC 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 PC 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 CN3163 package be soldered to the PC 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°

Consonance does not assume any responsibility for use of any circuitry described. Consonance reserves the right to change the circuitry and specifications without notice at any time.