CONSONANCE

PFM Step-up Multi-cell NIMH Battery Charger IC

CN3387

General Description:

CN3387 is a PFM mode step-up battery charge management IC with operating voltage range between 2.7V to 6.5V. It is specially designed for multi-cell NIMH battery charge management with fewer external components. CN3387 adopts constant current and maintenance mode to charge battery.

On power up, CN3387 enters constant current charging mode, the external N-channel MOSFET is turned on, inductor current rises. When inductor current reaches upper threshold, the N-channel MOSFET is turned off, then inductor is discharged, the energy stored in inductor is transferred to battery. When the inductor current is discharged to its lower threshold, the N-channel MOSFET is turned on again. When FB pin voltage rises to 1.124V (Typ.) , CN3387 enters maintenance mode, in which the input current is reduced, in the meantime a timer is started. The charge process will not be terminated until the time out occurs or FB pin voltage reaches 1.205V. In termination mode, the N-channel MOSFET is turned off. When FB pin voltage falls below recharge threshold, the CN3387 enters charge mode again. CN3387's switching frequency can be up to 1MHz, which makes a small-profile inductor usable.

If battery voltage is lower than input voltage by a diode drop, CN3387 will increase the off time to 5us to reduce the charge current as a protection for battery with the joint action of external N-channel and P-channel MOSFET.

The other features include chip enable input, status indication, etc.

CN3387 is available in 10-pin SSOP package.

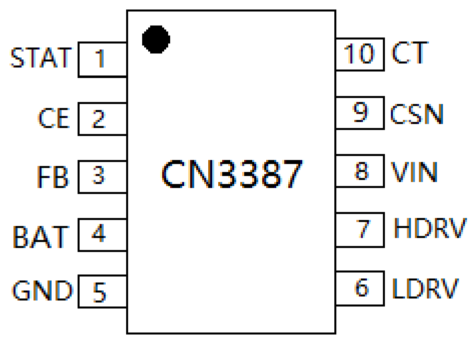
Applications:

- Standalone NIMH Battery Charger
- Electric Tools
- Toys
- Car Models, Aero-modeling

Features:

- Input Voltage Range：2.7V to 6.5V
- Operating Current：300uA@VIN=5V
- Inductor Current Detection
- Can be Powered by Solar-Panel
- Switching Frequency up to 1MHz
- Maintenance Charge Mode to Guarantee Fully-charged Battery
- Charging terminated by Timer
- Automatic Recharge
- Output Power up to 35W
- Protection for Low Battery Voltage and Short Battery
- Automatic Adaptability to Input Supply with Limited Driving Capability
- Chip Enable Input
- Battery Overvoltage Protection
- Status Indication
- Operating Temperature ：－40℃ to 85℃
- Available in SSOP10 Package
- Lead-free, rohs-Compliant and Halogen Free

Pin Assignment



Typical Application Circuit:

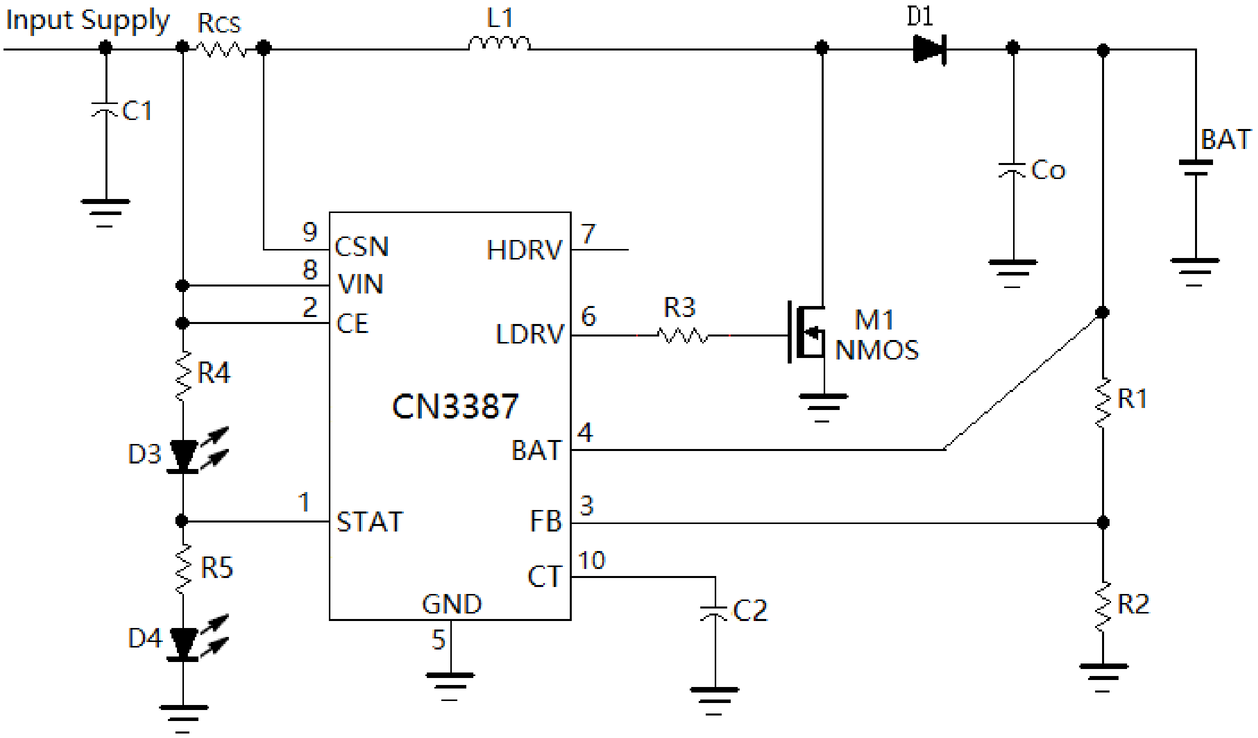


Figure 1 Typical Application Circuit (No protection for low or short battery)

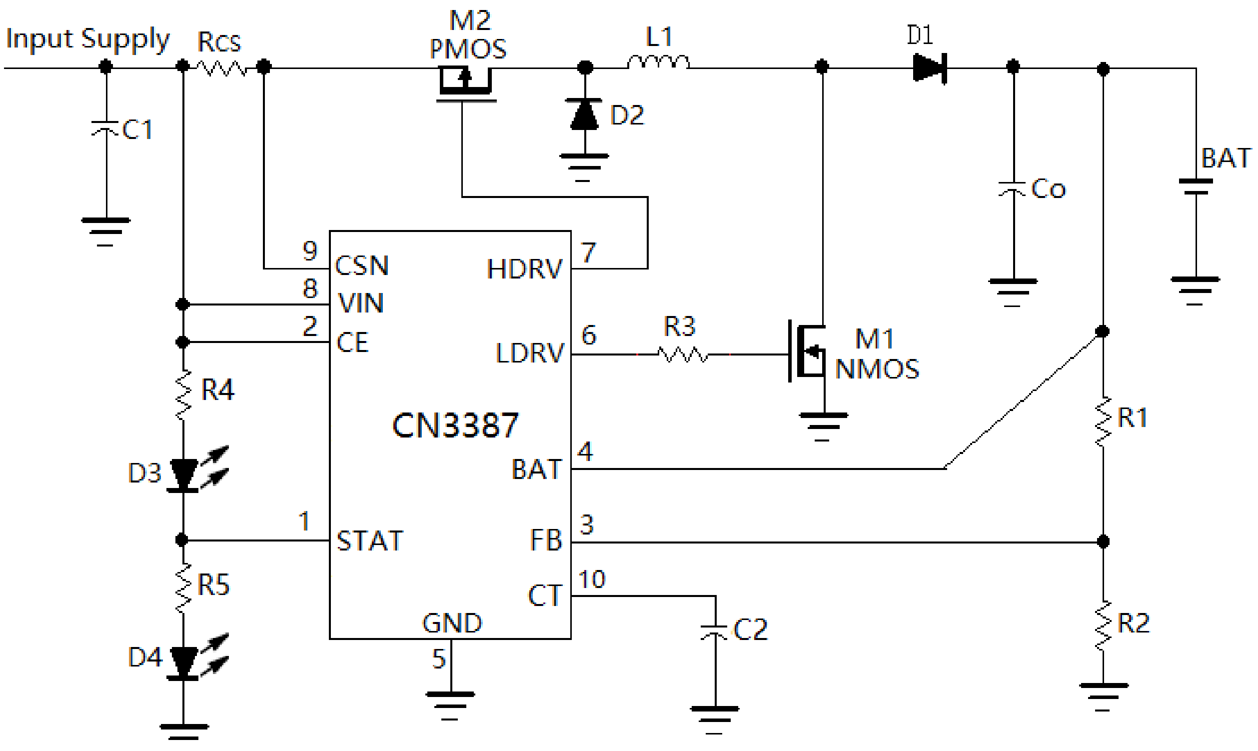


Figure 2 Typical Application Circuit (Protection for low or short battery)

Ordering Information:

Part No.	Package	Shipping	Operating Temperature
CN3387	SSOP-10	Tape and Reel, 4000/reel	－40℃ to 85℃

Block Diagram:

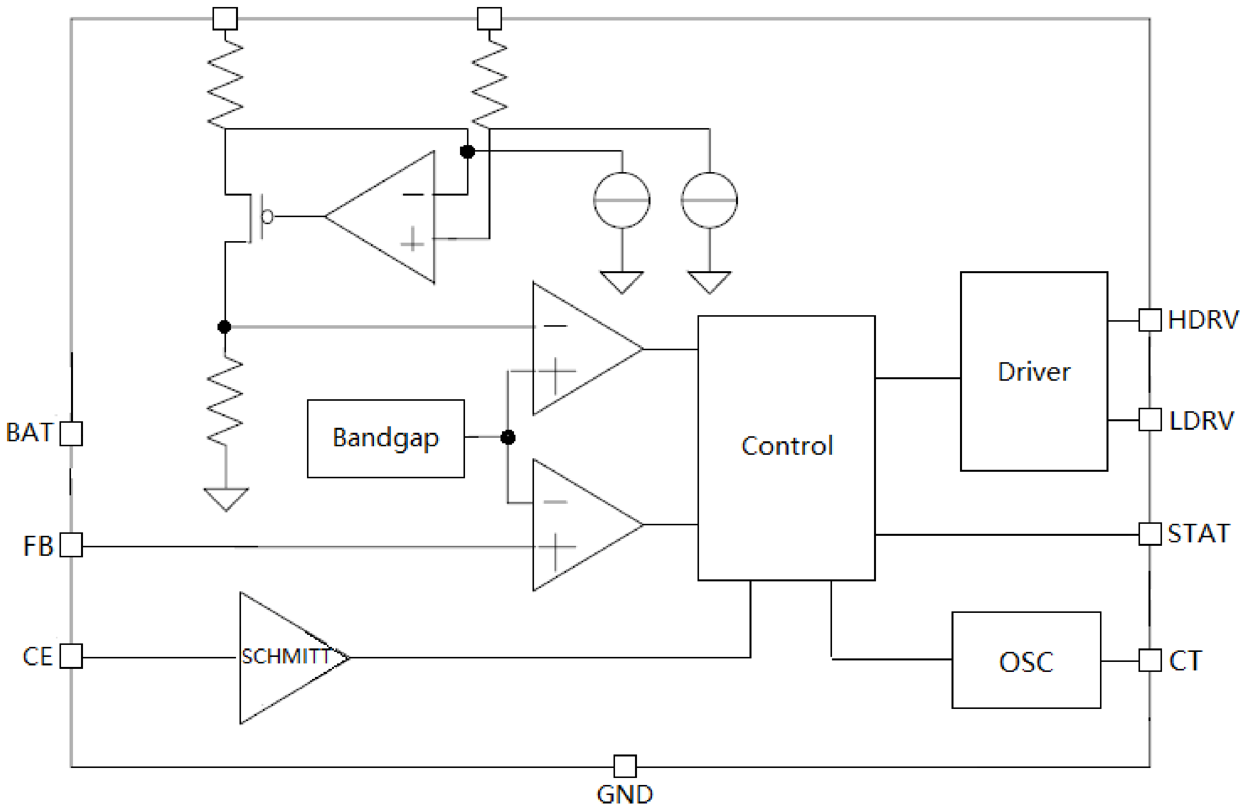


Figure 3 Block Diagram

Pin Description:

No.	Symbol	Description
1	STAT	**Status Indication Output.** CMOS output. STAT pin's being high means charger is in charging state; and charger is in termination state when STAT pin is low.
2	CE	**Chip Enable Input.** A high input will put the device in the normal operating mode. Pulling the CE pin to low level will put the CN3387 into disable mode. The CE pin can be driven by TTL or CMOS logic level.
3	FB	**Battery Voltage Feedback Input.** Battery voltage is fedback to the CN3387 through this pin. The CN3387 determines the charge mode based on the FB pin voltage. As shown in Figure 1, the battery terminal voltage at BAT pin : $V_{BAT} = V_{FB} \times (1 + R1 / R2)$
4	BAT	**Battery Positive Terminal.** BAT pin should be tied to battery's positive terminal to monitor battery voltage.
5	GND	**GND.** Ground, namely the negative terminal of input supply and battery.
6	LDRV	**Gate Drive for external N-Channel MOSFET.** Connect LDRV pin to the gate of external N-Channel MOSFET.
7	HDRV	**Gate Drive for external P-Channel MOSFET.** Connect HDRV to the gate of external P-Channel MOSFET. If there is no need to consider the cases such as battery voltage being lower than input supply or short battery, then the P-Channel MOSFET is not needed, and leave HDRV pin floating.
8	VIN	**Positive Terminal of Input Supply.** CN3387's internal circuit is powered by this pin, VIN is also the positive terminal of inductor current sensing.
9	CSN	**Negative Terminal of Inductor Current Sensing.** A current sense resistor R_{CS} between VIN pin and CSN pin is used to sense inductor current, also the input current. In constant current mode, (VIN－CSN) is regulated between 85mV and 125mV.
10	CT	**Timing Capacitor Connection Input.** The timing capacitor should be connected between CT pin and GND. The timing function is started once CN3387 enters maintenance mode, and the timing time is determined by the following equation: $t_{timing} = 12.18x10^{9}xC2$ Where C2 is the capacitance of capacitor C2 in Fig.1 and Fig.2.

ABSOLUTE MAXIMUM RATINGS

VIN, CSN and CE Voltage………..…−0.3V to 7.0V
BAT Voltage………………........……−0.3V to 18V
CSN and VIN Voltage……………..…−0.3V to 0.3V
STAT, LDRV and HDRV Voltage….. −0.3V to VIN
FB, CT Voltage………………………−0.3V to VIN

Maximum Junction Temperature.......………...150℃
Operating Temperature Range...........−40℃ to 85℃
Storage Temperature………........−65℃ to 150℃
Lead Temperature(Soldering, 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 beyond 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 CHARACTERICS:

(VIN = 5V, TA=−40°C to +85°C, Typical values are at TA=+25°C, unless otherwise noted)

<table>
<tr><th>Parameters</th><th>Symbol</th><th colspan="2">Test Conditions</th><th>Min</th><th>Typ.</th><th>Max</th><th>Unit</th></tr>
<tr><td>Input Voltage Range</td><td>VIN</td><td colspan="2"></td><td>2.7</td><td></td><td>6.5</td><td>V</td></tr>
<tr><td>UVLO Threshold</td><td>V_{UVLO}</td><td colspan="2"></td><td></td><td></td><td>2.65</td><td>V</td></tr>
<tr><td>Operating Current</td><td>I_{VIN}</td><td colspan="2">V_{FB}=1.5V, No Switching</td><td>230</td><td>300</td><td>370</td><td>uA</td></tr>
<tr><td>Turn-off Current</td><td>I_{off}</td><td colspan="2">CE is Low</td><td></td><td>0</td><td>2</td><td>uA</td></tr>
<tr><td>Switching</td><td>f_{SW}</td><td colspan="2"></td><td>200</td><td></td><td>1000</td><td>KHz</td></tr>
<tr><td colspan="8">Inductor Current Sense Comparator</td></tr>
<tr><td rowspan="2">Sense Threshold High</td><td rowspan="2">V_{CSHI}</td><td>CC</td><td rowspan="2">(VIN−V_{CSN}) rises from 0V until V_{LDRV} <0.5V</td><td>113</td><td>123</td><td>133</td><td rowspan="2">mV</td></tr>
<tr><td>Maintenance</td><td>62</td><td>72</td><td>82</td></tr>
<tr><td rowspan="2">Sense Threshold Low</td><td rowspan="2">V_{CSLO}</td><td>CC</td><td rowspan="2">(VIN−V_{CSN}) falls from 0.2V till V_{LDRV}>(VCC−0.5V)</td><td>77</td><td>87</td><td>97</td><td rowspan="2">mV</td></tr>
<tr><td>Maintenance</td><td>35</td><td>45</td><td>55</td></tr>
<tr><td>Propagation Delay to Output High</td><td>t_{DPDH}</td><td colspan="2">(VIN−V_{CSN}): 0.15V to 0.075V</td><td></td><td>72</td><td></td><td>ns</td></tr>
<tr><td>Propagation Delay to Output Low`</td><td>t_{DPDL}</td><td colspan="2">(VIN−V_{CSN}): 0.06V to 0.135V</td><td></td><td>66</td><td></td><td>ns</td></tr>
<tr><td>CSN Input Current</td><td>I_{CSN}</td><td colspan="2"></td><td></td><td></td><td>100</td><td>nA</td></tr>
<tr><td colspan="8">FB Pin</td></tr>
<tr><td>FB Highest Voltage</td><td>V_{high}</td><td colspan="2">FB voltage rises</td><td>1.193</td><td>1.205</td><td>1.217</td><td>V</td></tr>
<tr><td>FB Constant Charge Termination Voltage</td><td>V_{CCT}</td><td colspan="2">FB voltage rises</td><td>1.1</td><td>1.125</td><td>1.15</td><td>V</td></tr>
<tr><td>Recharge Threshold</td><td>V_{rech}</td><td colspan="2">FB voltage falls</td><td>1.08</td><td>1.105</td><td>1.13</td><td>V</td></tr>
<tr><td>FB Pin Current</td><td>I_{FB}</td><td colspan="2">V_{FB}=5.5V</td><td></td><td>0</td><td>100</td><td>nA</td></tr>
<tr><td>Over Voltage Threshold</td><td>V_{OV}</td><td colspan="2">FB voltage rises</td><td>1.255</td><td>1.285</td><td>1.315</td><td rowspan="2">V</td></tr>
<tr><td>Over Voltage Release Threshold</td><td>V_{OVRLS}</td><td colspan="2">FB voltage falls</td><td>1.205</td><td>1.235</td><td>1.265</td></tr>
</table>

(Continued from Last Page)

Parameters	Symbol	Test Conditions	Min	Typ.	Max	Unit
BAT Pin						
BAT Pin Sink Current	I_{BAT}	V_{BAT}＝12V	4.6	5.8	7	uA
LDRV Pin						
LDRV Source Current		V_{CSN}＝VIN, V_{DRV}＝0.5×VCC		0.65		A
LDRV Sink Current		V_{CSN}＝VIN－0.2V，V_{LDRV}＝0.5×VCC		0.65		A
LDRV Output High	V_{OH}	I_{LDRV}＝5mA	VCC－0.3			V
LDRV Output Low	V_{OL}	I_{LDRV}＝－5mA			0.3	V
HDRV Pin						
HDRV Source Current		V_{CSN}＝VIN－0.2V, BAT Short to GND, V_{HDRV}＝0.5×VCC		0.8		A
HDRV Sink Current		V_{CSN}＝VIN，BAT short to GND V_{HDRV}＝0.5×VCC		0.8		A
HDRV Output High	V_{OH}	I_{HDRV}＝5mA	VCC－0.3			V
HDRV Output Low	V_{OL}	I_{HDRV}＝－5mA			0.3	V
CE Pin						
Input Low Voltage	V_{CEL}	CE voltage falls			0.7	V
Input High Voltage	V_{CEH}	CE voltage rises	2.2			V
Input Current	I_{CEL}	CE=GND，VIN=6V	－1			uA
	I_{CEH}	CE=VIN=6V			1	uA
STAT Pin						
Sink Current	I_{SINK}	V_{STAT}=0.3V，Termination mode		10		mA
Source Current	I_{SRC}	V_{STAT}=4.7V， Charge mode		10		mA

Detailed Description：

The CN3387 is a step-up charge management IC for multi-cell NIMH batteries with input voltage range from 2.7V to 6.5V.

The CN3387 is composed of reference voltage, inductor current sensing circuit, battery voltage detection circuit, battery over voltage protection circuit, low battery protection, logic control block and MOSFET driver, etc. The CN3387 is ideally suitable for multi-cell NIMH batteries charging application with fewer external components. After power-on, CN3387 enters constant current charging mode, STAT pin outputs high to indicate that the charging is ongoing, the external N-channel MOSFET is turned on, the inductor current rises, and the energy stored in the output capacitor is transferred to battery. When the inductor current rises to the upper threshold, the N-channel MOSFET is turned off, the inductor current begins to fall, the energy stored in the inductor is transferred to the battery and the output capacitor. When the inductor current falls to the lower threshold, the external N-channel MOSFET is turned on again, and so forth. The battery voltage is sensed by the resistor divider at FB pin. When the FB pin voltage reaches 1.125V(Typical), CN3387 enters maintenance mode. In maintenance mode, the input current is reduced to 66% of that in constant current mode. Once CN3387 is in maintenance mode, an on-chip timer is started, and the charging will not be terminated until the time out occurs or FB pin voltage reaches 1.205V. In termination mode, the external N-channel MOSFET is turned off, there is no current flowing to the battery, STAT pin outputs low to indicate the termination mode. when the battery voltage falls to 1.105V(Typical), CN3387 enters constant current mode again.

The highest switching frequency of CN3387 can be up to 1MHz, which makes the low-profile inductor usable.

CN3387 is a step-up charger IC, which means the battery voltage should be higher than the input voltage. In certain extreme cases, the battery voltage may be lower than the input voltage, or even the battery is shorted to GND, if these are the cases, the off-time of the external N-channel MOSFET will be lengthened, hence the charge current is reduced as a kind of protection to the battery.

The other functions include chip enable input (CE pin), battery over voltage protection, etc..

The charge profile is illustrated in Figure 4.

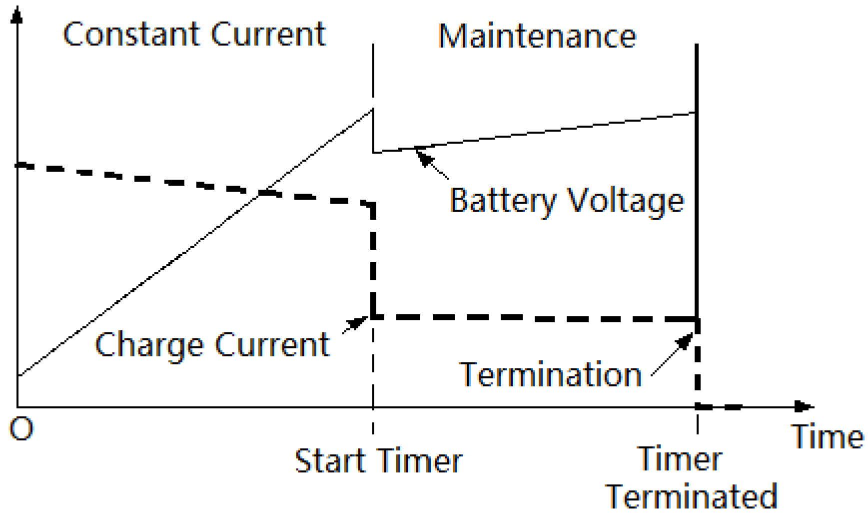


Figure 4 Charging Profile

The charging flow is illustrated in Figure 5.

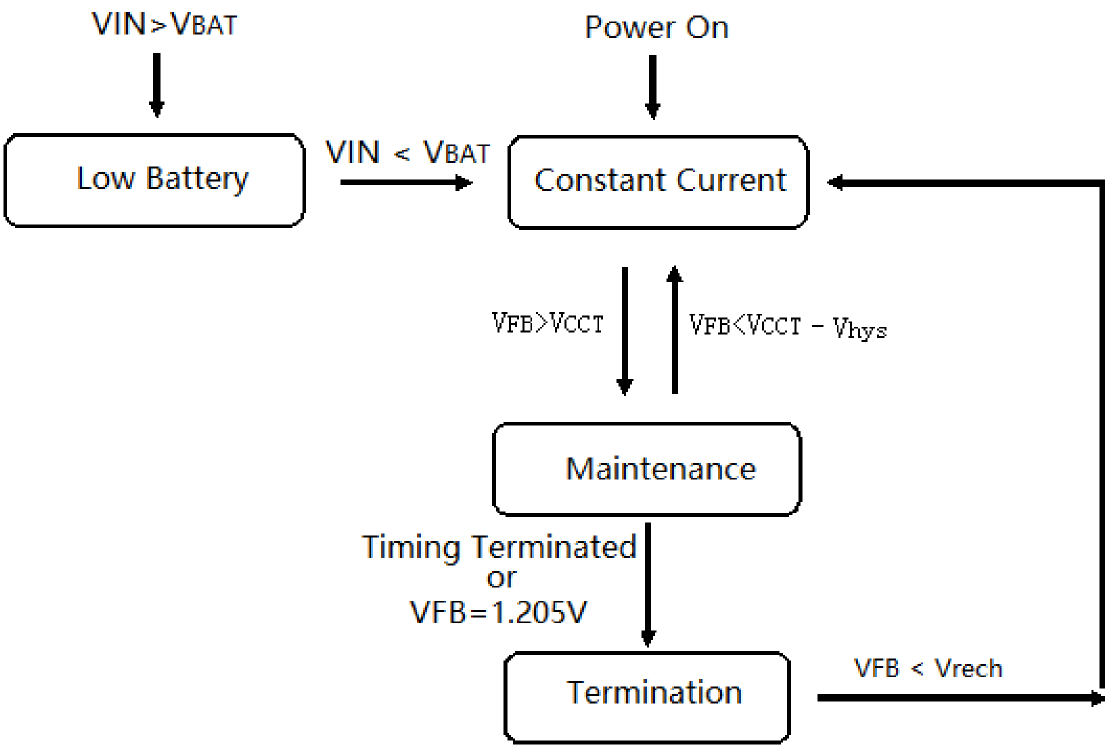


Figure 5 Charging Flow

Application Information:

Input Voltage Range

The CN3387 functions well when the input voltage is between 2.7V to 6.5V. On-chip UVLO circuit will shut down the CN3387if input voltage falls below UVLO threshold (2.65V Max.).

Chip Enable/Disable

There is a chip enable input CE pin. When the voltage at CE pin is above 2.2V, CN3387 functions normally; When the voltage at CE pin is below 0.7V, CN3387 is turned off. In turn-off state, the operating current is quite small (2uA Max.).

Do not apply a voltage between 0.7V and 2.2V on CE pin, otherwise CN3387 may be in uncertain state.

FB Voltage and the Battery Terminal Voltage

As shown in Figure 1 and Figure 2, the battery terminal voltage is fed back to FB pin through the resistor divider formed by R1 and R2, the CN3387 determines the charge mode based on FB pin voltage.

The battery terminal voltage(BAT pin) can be found by:

$$V_{BAT} = V_{FB} \times (1 + R1 / R2)$$

The Maximum Battery Terminal Voltage

The maximum battery terminal voltage is the voltage that the battery may reach during the charge cycle, however, this is not necessarily happen due to the fact that NiMH battery's voltage may drop a bit when it is nearly full. Once the battery voltage reaches the maximum battery terminal voltage, the CN3387 terminates the charge cycle. So this is a protection mechanism to the battery.

When battery is absent, the voltage at BAT pin may be charged to over voltage protection level as CN3387 takes the output capacitor as the battery.

Maintenance Charge Mode

If the voltage at FB pin rises above 1.125V(93.3% of FB maximum voltage), the constant current charge mode is stopped, and the CN3387 goes into the maintenance charge mode. The inductor current in maintenance mode is 66% of that in constant current mode. An internal timer is started once the CN3387 is in the maintenance charge mode, this puts a time limit on the maintenance charge mode, the time limit is programmed by a capacitor at the CT pin as shown in Figure 1 and Figure 2. After the time out occurs, the whole charge cycle is terminated, the CN3387 enters into termination mode.

In maintenance charge mode, the time limit is determined by the following equation:

$$T = 12.18 \times 10^9 \times C2$$

Where:

- T is the time limit in second
- C2 is the capacitance of C2 in Figure 1 and Figure 2, the unit is Farad, C2 should be greater than 1nF, otherwise the timer's accuracy may be affected. If multi-layer ceramic capacitor is used as the timing capacitor, it is better to use 1uF or 2.2uF capacitor whose package size is 0805 or 1206.

Inductor Current（Input Current）

In the application circuit shown in Figure 1 and Figure 2, inductor current is sensed via the resistor R_{CS} connected between VIN and CSN pin.

When the external N-channel MOSFET is on, inductor current rises, when it reaches the upper threshold:

$$I_{Lhigh} = 0.123V / R_{CS} \quad \text{（CC Mode）}$$

$$I_{Lhigh} = 0.075V / R_{CS} \quad \text{（Maintenance Mode）}$$

The N-channel MOSFET is turned off.

When the external N-channel MOSFET is off, inductor current falls, the energy is transferred to battery from inductor. When inductor current falls to:

$I_{Llow} = 0.087V / R_{CS}$ （CC Mode）

$I_{Llow} = 0.045V / R_{CS}$ （Maintenance Mode）

The external N-channel MOSFET is turned on again, a new cycle is started.

So the average inductor current is: $I_L = 0.105V / R_{CS}$ （CC Mode）

$I_L = 0.068V / R_{CS}$ （Maintenance Mode）

In the above 3 equations,

I_{Lhigh} is upper threshold of inductor current in Ampere

I_{Llow} is lower threshold of inductor current in Ampere

R_{CS} is the inductor current sense resistor in ohm (Ω)

Calculate Switching Frequency and Inductor

In the application circuit shown in Figure 1 and Figure 2, the on-time of external N-channel MOSFET is:

$$t_{on} = \frac{0.04 \times L}{VIN \times R_{CS}} \quad \text{-------------} \quad (1)$$

The off-time of the N-channel MOSFET is:

$$t_{off} = \frac{0.04 \times L}{(V_{BAT} + V_D - VIN) \times R_{CS}} \quad \text{--------} \quad (2)$$

So the switching frequency is:

$$f_{sw} = \frac{1}{t_{on} + t_{off}} = \frac{1}{\dfrac{0.04 \times L}{VIN \times R_{CS}} + \dfrac{0.04 \times L}{(V_{BAT} + V_D - VIN) \times R_{CS}}}$$

CN3387 requires that the minimum switching frequency is no less than 200KHz. A frequency between 200KHz and 600KHz can achieve a good balance between efficiency and inductor size.

The switching frequency varies with input voltage and battery voltage

Based on the requirements of input voltage range, charge current and switching frequency, the inductor value varies between 3.3uH and 15uH.

The duty cycle of CN3387 LDRV pin:

$$D = \frac{t_{on}}{t_{on} + t_{off}} = \frac{V_{BAT} + V_D - VIN}{V_{BAT} + V_D}$$

In the above 2 equations, L is the inductor value in Henry(H)

VIN is the input voltage in Volt

V_{BAT} is battery voltage in Volt

V_D is the forward voltage drop of diode in Volt

R_{CS} is the inductor current sense resistance in ohm(Ω)

Estimate Charge Current in Constant Current Mode

CN3387 controls charge current by monitoring inductor current, so the charge current in CC mode may vary with the input voltage and battery voltage.

Normally the following equation can be used to estimate the charge current:

$$I_{CH} = \frac{VIN \times I_L \times \eta}{V_{BAT}}$$

Where,

I_{CH} is charge current in Ampere

VIN is input voltage in Volts

I_L is the average inductor current in Ampere, and decided by 0.106 / R_{CS}

η is the conversion efficiency varying between 80% and 93%.

V_{BAT} is battery voltage in Volt

Charge Termination

When the time out occurs or FB pin voltage reaches 1.205V(Typical) in maintenance mode, the charge cycle is terminated, the external N-channel MOSFET is turned off, no current flows to battery.

Recharge

In termination mode, if voltage at FB pin falls below 1.105V(Typical), CN3387 enters charge mode again.

Selection of N-Channel MOSFETN

The CN3387's gate driver is capable of sourcing 0.65A and sinking 0.65A of current. MOSFET selection is based on the maximum battery voltage, inductor current and operating switching frequency. Choose an N-channel MOSFET that has a higher breakdown voltage than the maximum battery voltage, low Rds(ON), and low total gate charge(Qg) for better efficiency. MOSFET threshold voltage must be adequate if operated at the low end of the input-voltage operating range.

Selection of Free-Wheeling Diode

The forward voltage of the freewheeling diode (D1 in Fig.1 and Fig.2) should be as low as possible for better efficiency. A Schottky diode is a good choice as long as the breakdown voltage is high enough to withstand the maximum battery voltage. The forward current rating of the diode must be at least equal to the maximum charge current.

D2 in Fig.2 is only used when the input voltage is higher than battery voltage, in this case the inductor current is lowered much, and the maximum voltage applied on the diode is input voltage, so most of the schottky diodes can be used for D2.

Input Capacitor

In most applications, a bypass capacitor at VIN is needed. An at least 4.7uF 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. The capacitor's breakdown voltage should be higher than the maximum input voltage.

Generally a capacitor between 4.7uF and 47uF works well, ceramic capacitor of X5R or X7R is highly recommended.

Output Capacitor

A filter capacitor (Co in Figure 1 and Figure 2) is needed between battery positive terminal and ground, the capacitor also supply energy to battery when the N-channel MOSFET is in on state.

The output capacitance is determined by the requirement of output ripple voltage. The ripple voltage is decided by the following equation:

$$\Delta V_{BAT} = \frac{I_{CH} \bullet t_{off}}{Co} + \frac{0.04 \bullet r_{esr}}{Rcs}$$

Where， I_{CH} is the charge current flowing into battery

t_{off} is the off time of N-channel MOSFET

Co is the output capacitance

resr is the equivalent series resistance of output capacitor

Rcs is the inductor current sense resistor shown in Figure 1 and Figure 2

So the ESR of the output capacitor should be as small as possible, X5R or X7R capacitors are recommended.

Battery Absence

When the battery is not present, the CN3387 takes the output capacitor as battery and charges it quickly to over voltage protection level, then the battery voltage decays slowly to recharge threshold because of low battery current, so the CN3387 will toggle between charge and termination mode, which results in a sawtooth waveform at battery positive terminal, in the meantime, STAT pin outputs.a pulse.

Status Indication

CN3387's CMOS output STAT pin is for status indication. In charge state, STAT pin outputs high; In charge termination state, STAT pin outputs low.

STAT pin can drive LEDs directly or interface with MCU.

In the application circuit shown in Figure 1 and Figure 2, STAT pin is driving LEDs.

When STAT pin interfaces with MCU, if CN3387's operating voltage is higher than MCU's power supply, then the circuit shown in Figure 6 can be used:

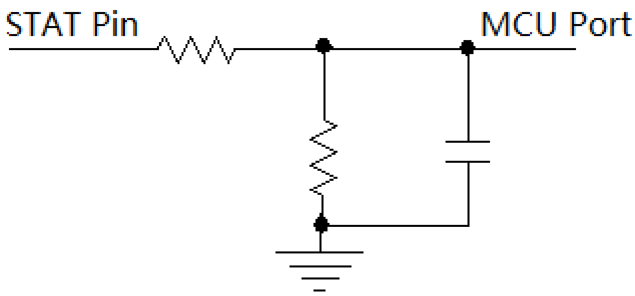


Figure 6 STAT Pin Interfaces with MCU

If 2 common-anode or common-cathode LEDs are to be driven, then the circuits in Figure 7 can be used.

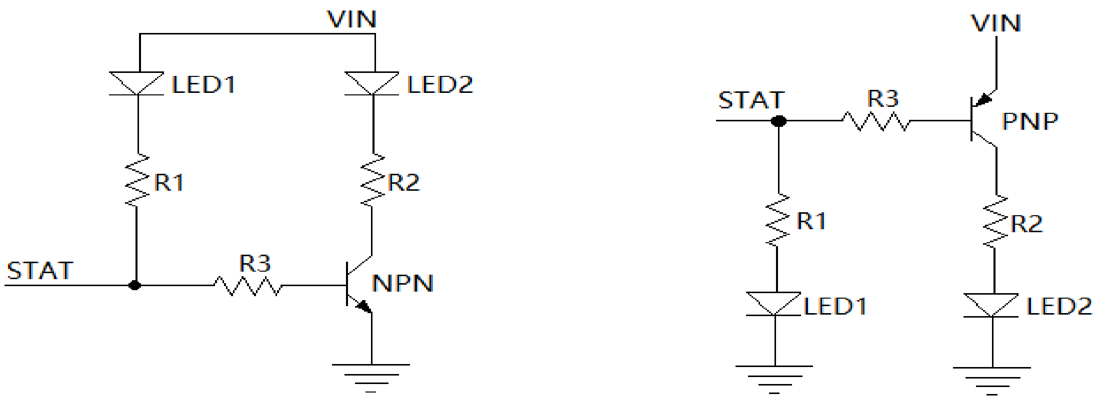


Figure 7 Drive 2 common-anode or common-cathode LEDs

When chip enable input is low, STAT pin outputs high, the LED for charge indication will be turned on. To turn off the LED when CE is low, the circuit in Figure 8 can be used.

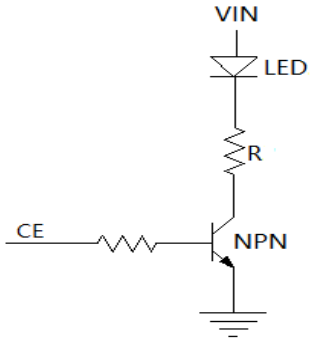


Figure 8 To Turn off LED when CE is low

Low Battery or Shorted Battery Protection

In normal operation, the battery voltage is higher than the input voltage. But in some cases, the battery voltage may be lower than input voltage, or even the battery is shorted to Ground. In these cases, the application circuit shown in Figure 2 should be adopt, otherwise the uncontrolled current may be flowing from input supply to the battery through the inductor and diode, which may be harmful to battery.

Self-adaptive Function to Input Supply

CN3387 can adjust the inductor current automatically to adapt the input supply's output capability. This feature makes it possible that the circuit design can be done based on the adaptor with strong output capability for quick charge purpose, while the adaptor with weaker output capability can also be used for charge purpose.

In self-adaptive mode, the input voltage may falls down to 2.6V, so the external MOSFETs should be selected in such a way that they are fully turned on at about 2.6V.

This function can make CN3387 be powered by solar panel.

Design Procedures

The following design procedures can be followed to design the parameters of CN3387 application circuit:

（1） To determine the charge current and the timing time in maintenance mode according to the battery capacity and the requirement of charge time.

In maintenance mode, empirically an amount of energy of 55% of battery capacity should be charged into battery. Suppose battery capacity is C, so the timing time should be:

$$T = 0.55C / 0.66I_{CH}$$

（2） To decide the capacitor C2 based on the timing time.

Timing time $T = 12.18 \times 10^9 \times C2$

（3） To decide the resistor divider R1 and R2 based on the number of series-connected battery.

The maximum battery voltage should be set at 1.46V x n, where n is the number of series-connected battery, namely:

$$1.46V \times n = 1.205 \times (1+R1 / R2)$$

R2 can be set at around 100K ohm.

（4） To estimate the input current based on the input voltage range and charge current. The input current is also the inductor current.

（5） To decide the input capacitor based on the input supply's characteristics, input supply's cable length and input current.

（6） To select diode, N-channel MOSFET and P-channel MOSFET based on input voltage, inductor current and the battery's highest voltage.

（7） To calculate the current sense resistor R_{CS} based on the average inductor current

（8） To determine the inductor value according to the switching frequency. The switching frequency can be from 200KHz to 1MHz. Generally speaking, a switching frequency between 300KHz and 600KHz can achieve a good balance between efficiency and inductor's profile.

（9） To select the output capacitor based on the switching frequency and charge current.

Design Example

The circuit parameters for Figure 1 and Figure 2 are shown in the following table for some typical scenarios. The circuit parameters are designed based on typical conditions without considering the specific application conditions and the environmental factors. The circuit parameters shown in the table are for reference only.
(VIN=5V, 7 NIMH batteries in series connection, I_{CH} is charge current, unless otherwise specified)

Input Current or Inductor Current	**0.9A**	**1.8A**	**3.6A**	**5.4A**	**7.2A**
Input Cap C1	10uF,0805	22uF,1206	22uF,1206 2X in parallel	22uF,1206 3X in parallel	22uF,1206 4X in parallel
Diode D1	SS24 or SS34	SS24 or SS34	SS24 or SS34	SS54 or 1N5824	SS54 or 1N5824
Diode D2	SS24 or SS34	SS24 or SS34	SS24 or SS34	SS34	SS34
NMOS M1	SI2300,SI2302	AO4468	AO4468, AO4410	AO4410, NCE3018S	AON7140
PMOS M2	SI2301,SI2305	AO4435	AO4435	AO4407A	AO4407A
Current Sense Resistor R_{CS}	120mΩ, 0.15W	60 mΩ,0.25W	30 mΩ,0.5W	20 mΩ,1W	15 mΩ,1W
Inductor L1	10uH, I_{SAT}>2A	6.8uH,I_{SAT}>3A	3.3uH,I_{SAT}>5A	2.2uH,I_{SAT}>7.5A	2.2uH,I_{SAT}>7.5A
Switching Frequency	560KHz	415KHz	420KHz	420KHz	320KHz
Output Cap Co	10uF,0805	22uF,1206	22uF,1206 2X in parallel	22uF,1206 3X in parallel	22uF,1206 4X in parallel

About EMI Reduction

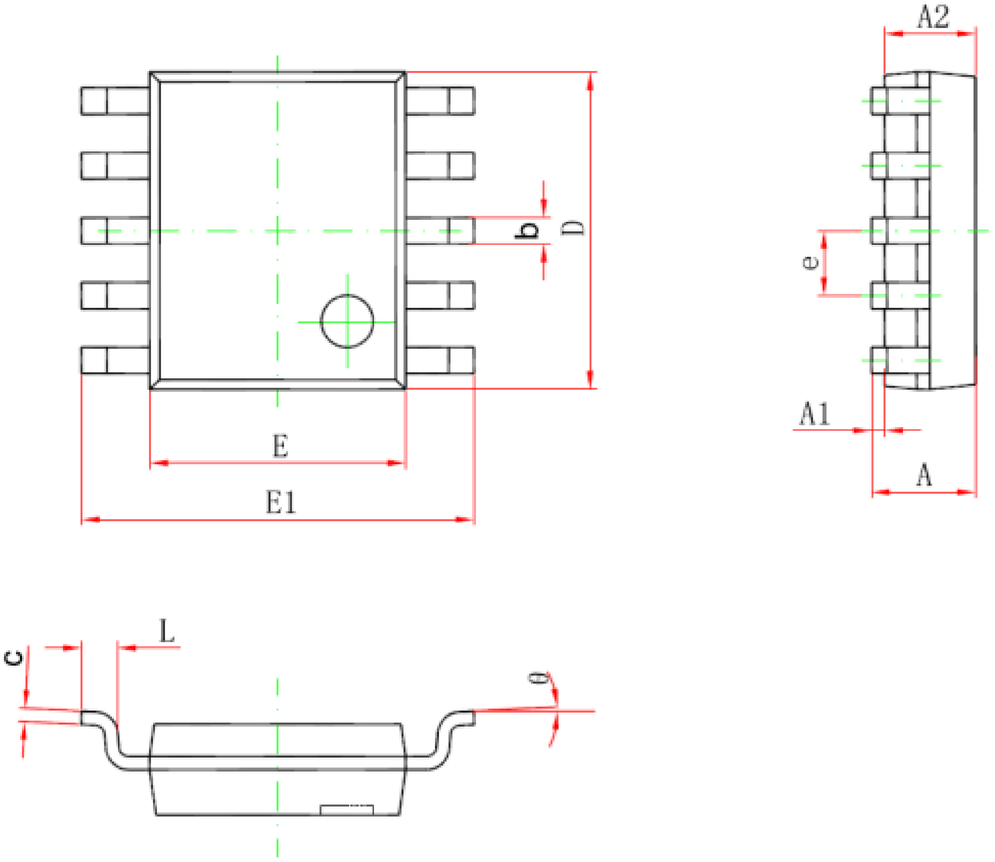
EMI performance is highly dependent on the circuit design, component selection and PCB design, etc.
CN3387's LDRV pin adopts good drive capability to meet the requirement of outputting 35W power. If the LDRV's rise time and fall time is very short due to small Qg of external N-channel MOSFET, which may bring high frequency EMI. In these cases, a resistor(R3 in Figure 1 and Figure 2) can be used to reduce EMI.
R3's resistance should be chosen such that LDRV's rise time and fall time is at about 60ns.

PCB Considerations

A good PCB design is very important to efficiency and performance. When laying out the printed circuit board, the following considerations should be taken to ensure proper operation of the IC.

- If possible, use multi-layer PCB for better performance.
- The ground connections of output capacitor, N-channel MOSFET, and catch diode (D2 in Figure 2) need to feed into same copper that connects to the input capacitor ground before tying back into system ground. This copper should be as wide as possible, and back to system ground separately.
- To minimize radiation, the 2 diodes, MOSFETs, inductor and the input bypass capacitor traces should be kept as short as possible. The connection between the diode and the MOSFETs should also be kept as short as possible.
- Place the inductor current sense resistor R_{CS} right next to the input capacitor and inductor but oriented such that the IC's CSN and VIN traces going to R_{CS} are not long. The 2 traces need to be routed together as a single pair on the same layer at any given time with smallest trace spacing possible.

Package Information



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.300	0.450	0.012	0.018
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.000(BSC)		0.039(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	1°	8°