PFM buck mode single NiMH battery charge management IC

CN3600

Overview:

CN3600 is a fixed off-time PFM mode buck single-cell NiMH battery charge management IC. CN3600 has an input voltage range of 2.7V to 6.5V, few external components, and simple application, making it very suitable for single-cell NiMH battery charge management applications.

CN3600 uses constant current and maintenance charging modes to charge a single NiMH battery. After power-on, CN3600 first uses constant current mode to charge the battery. When the battery voltage reaches 1.36V, it enters maintenance charging mode and starts the internal timer. In maintenance charging mode, it enters the end state only when the timer ends or the battery voltage reaches the maximum voltage (typical value 1.46V). In the end state, no current flows into the battery. When the battery voltage drops below the recharge threshold, it automatically enters the recharge mode and starts a new charging cycle.

The switching frequency of CN3600 can reach 500KHz, and small inductors and capacitors can be used.

Other functions include two open-drain status indication outputs, battery overvoltage protection and chip overtemperature protection.

CN3600 is available in 8-pin eSOP package.

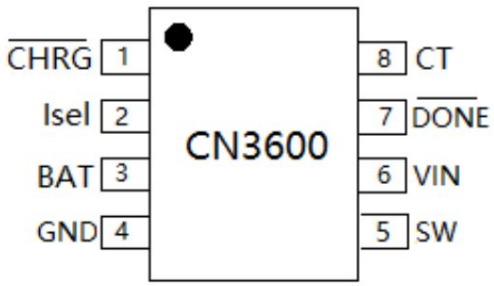
application:

ÿ Standalone NiMH battery charger ÿ Model cars ÿ Toys ÿ Devices using AA or AA batteries

Features:

ÿ Input voltage range: 2.7V to 6.5V ÿ Operating current: 320uA@VIN=5V ÿ Automatically adjust charging current according to input power load capacity ÿ Can be powered by solar panels ÿ Switching frequency up to 500KHz ÿ Maintain charging mode to ensure full battery ÿ Selectable inductor current peak (ipeak) ÿ Battery voltage reaches 1.46V or charging ends by timer ÿ Automatic recharge function ÿ Battery overvoltage protection ÿ Chip overtemperature protection ÿ Two open drain status indication outputs ÿ Operating ambient temperature range: -40ÿ to 85ÿ ÿ Adopt eSOP-8 package ÿ The product is lead-free, meets RoHS, and does not contain halogen

Pin Arrangement



Typical application circuit:

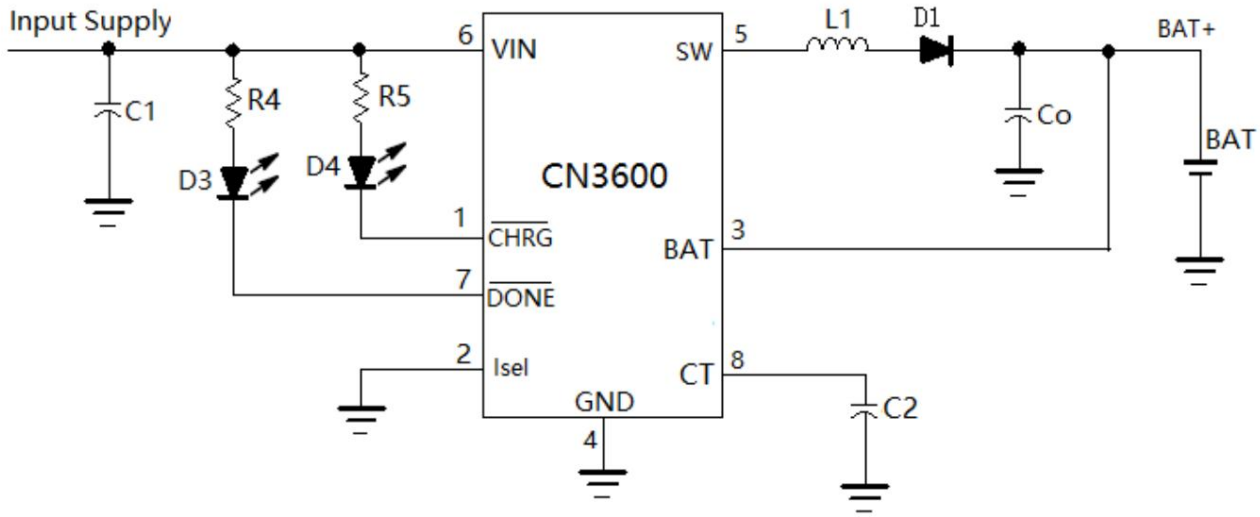


Figure 1 Typical application circuit

Ordering Information:

Model Packaging			Operating temperature
CN3600	SOP-8 Tape, Reel, 4000pcs/reel		-40ÿ to 85ÿ

Pin Description:

Serial number	symbol	describe
1	$\overline{CHRG}$	Charging status indication output. Open drain output. In charging state (constant current mode or maintaining In charging mode, this pin is pulled low by the internal N-channel MOSFET. The pin outputs high impedance.
2	Isel	Inductor current peak selection input terminal. When this pin is high, the inductor current in constant current charging mode The peak value (ipeak) is 1.19A (typical value); when this pin is low, the inductor of the constant current charging mode The peak current is 0.62A (typical). The ISEL pin accepts TTL logic levels or CMOS logic levels.
3	BAT	Battery positive connection terminal. Battery voltage is fed back to CN3600 through this pin. CN3600 The voltage on the pin determines the charger status.
4	GND	Ground connection terminal. Negative connection terminal for input power and battery.
5	SW	Inductor connection terminal. The SW pin is connected to an external inductor. Inside the chip, the SW pin is connected to a P channel MOSFET and an N-channel MOSFET.
6	VIN	Positive input power supply. The internal circuit of CN3600 is powered by this pin.
7	$\overline{DONE}$	End status indication output. Open drain output. When charging is completed, this pin is internally switched on. In other states, this pin outputs high impedance.
8	CT	Timing capacitor connection terminal. The timing capacitor should be connected between the CT pin and ground. Maintain charging status and start the timer. The timing is determined by the following formula: ttiming = 12.18 x 109 x C2 (Second) where C2 is the timing capacitor value in Farads.

Limit parameters

VIN and Isel pin voltage……ÿ0.3V to 7.0V Maximum junction temperature……150ÿ

BAT pin voltage……ÿ0.3V to 7.0V Operating temperature……ÿ40ÿ to 85ÿ

$\overline{CHRG}$ Pin voltage……ÿ0.3V to VIN Storage temperature……ÿ65ÿ to 150ÿ

SW and CT pin voltage…… ...

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, TA = -40°C to +85°C, typical values are measured at TA = +25°C unless otherwise specified)

	symbol	Test conditions		Min.Typ.Max.Unit			
Parameter Input voltage range	VIN			2.7		6.5 V	
UVLO threshold	VUVLO					2.65 V	
Operating current	IVIN	VBATÿ2.1V, no switch toff charging		250	320	390uA	
Fixed off time Over	mode			1.6	2.0	2.4	uS
temperature protection	TTP				145		°C
threshold Over temperature	Hopt				twenty one		°C
protection hysteresis Inductor current							
Inductor current peak	ipeak	Constant current charging	Isel high level		1.19		A
		Maintain charging			0.62		
		constant current charging	Isel low level		0.64		
		Maintaining Charge			0.44		
BAT pin							
Battery terminal maximum voltage Vhigh		BAT pin voltage rises		1.445	1.46	1.475 V	
Constant current charging end voltage VCCT		BAT pin voltage rises		1.34	1.36	1.38 V	
Recharge Threshold	Vrech	BAT pin voltage drops		1.32	1.339	1.36 V	
BAT pin current	IBAT	VBATÿ1.5V		4.7	6.3	8uA	
Battery overvoltage protection threshold VOV		BAT voltage rises		1.527	1.557	1.587	V
Battery overvoltage protection release threshold VOVRLS		BAT voltage drops		1.466	1.496	1.526	
SW pin							
N-channel MOSFET conduction Resistance	RdsonN	N-channel MOSFET at SW pin and Between GND			0.3		ohm
P-channel MOSFET conduction Resistance	RdsonP	P-channel MOSFET at SW pin and Between VIN			0.4		ohm
Isel pin							
Input low level	VL	Isel pin voltage drops				0.7 V	
Input high level	VH	Isel pin voltage rises		2.2			V
Input Current	IL	Isel=GNDÿVIN=6V		-100			nA
	IH	Isel=VIN=6V				100	
$\overline{\text{CHRG}}$ Pins							
Sinking and	ISINK	VCHRG=0.3V, charging mode			10		mA
Sinking	ILEAK	VCHRG=6V, charging is completed				100 nA	
$\overline{\text{DONE}}$ Current Pins							
Sinking current	ISINK	VDONE=0.3V, charging is finished			10		mA
Leakage current	ILEAK	VDONE=6V, charging mode				100 nA	

Detailed description:

CN3600 is a fixed off-time PFM buck mode single-cell NiMH battery charging management integrated circuit. The input voltage range of CN3600 is 2.7V to 6.5V. CN3600 includes circuit units such as voltage reference source, inductor current detection unit, battery voltage feedback network, battery overvoltage protection, chip overtemperature protection, control unit and power MOSFET switch. It has few peripheral components and simple application, which is very suitable for single-cell NiMH battery charging applications. After the input power is powered on, CN3600 enters constant current charging mode, and the pin outputs a low level, indicating that charging is in progress. During the conduction period of the internal P-channel MOSFET, the inductor current rises. When it rises to the set peak current, the P-channel MOSFET is turned off, and the other N-channel MOSFET is turned on, the inductor current decreases, and the energy in the inductor is transferred to the output capacitor and the battery. The off time of the P-channel MOSFET is fixed at 2 microseconds. After the off time ends, the N-channel MOSFET is turned off and the P-channel MOSFET is turned on, and so on. The battery voltage is detected through the BAT pin. When the BAT pin voltage reaches 1.36V (typical value), CN3600 enters the maintenance charging mode. In the maintenance charging mode, the peak current of the inductor is smaller than the peak current of the constant current charging mode. The timer inside the chip starts in the maintenance charging mode. When the timer ends or the battery voltage reaches the maximum voltage (typical value 1.46V), the charging process ends. At the end of charging, the P-channel MOSFET inside the chip is turned off, no current flows to the battery, and the pin outputs a low level, indicating that charging is over. When the BAT pin voltage drops to 1.339V (typical value), CN3600 enters the constant current charging mode again and starts a new charging cycle.

$\overline{CHRG}$

$\overline{DONE}$

The switching frequency of CN3600 can reach 500KHz, and small-sized inductors and capacitors can be used.

Other functions include inductor current peak value selectable through the Isel pin, battery overvoltage protection, chip overtemperature protection, etc. The charging current/voltage curve is shown in Figure 2:

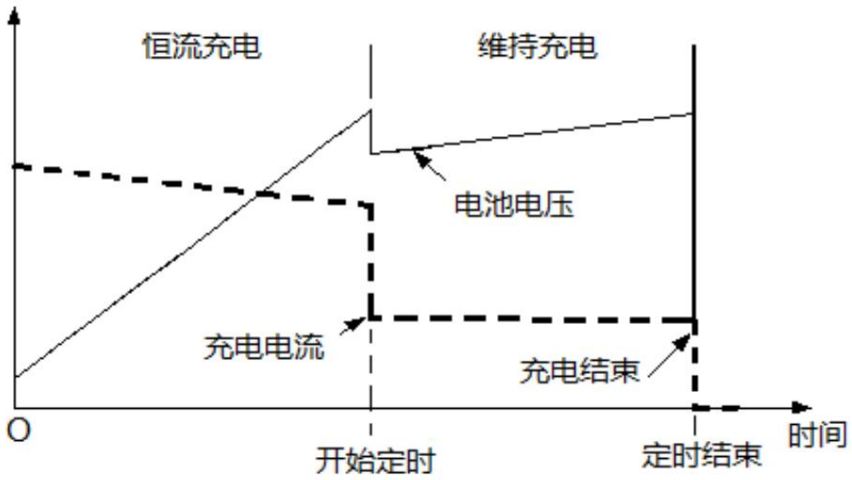


Figure 2 Charging current/voltage curve

The charging process is shown in Figure 3:

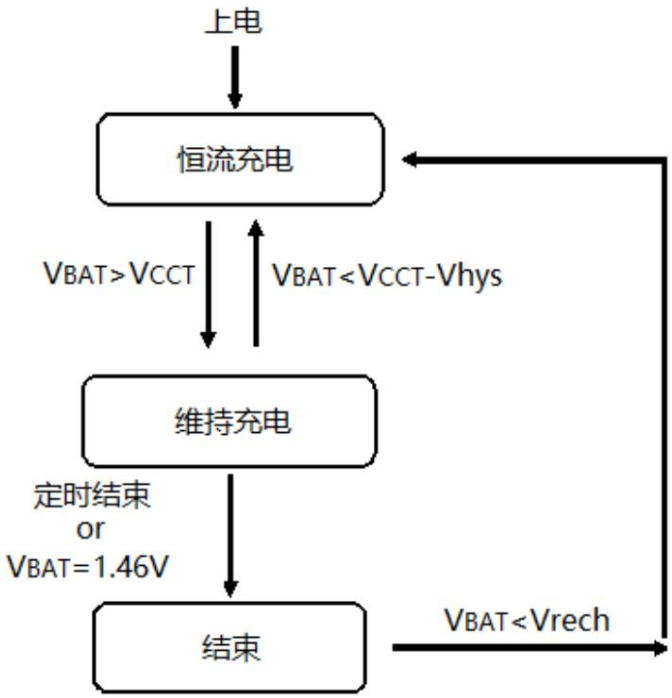


Figure 3 Charging process

Application Information:

Input voltage range

The operating voltage range of CN3600 is 2.7V to 6.5V. The UVLO unit inside the chip is locked when the input voltage is lower than the low voltage latch threshold (maximum 2.65V) will shut down the internal circuit.

Inductor current peak **(ipeak) selection**

The Isel pin is used to select the peak value of the inductor current. When the internal P-channel MOSFET is turned on, the inductor current rises. When the inductor current reaches Isel, When the peak value set by the pin is reached, the internal P-channel MOSFET is turned off.

The inductor current peak value (ipeak) is shown in Table 1:

Isel	Status	**Inductor current peak value (ipeak)**
High level	Constant current charging	1.19A
	mode Maintain charging	0.62A
Low level	mode Constant current	0.64A
	charging mode Maintain charging mode	0.44A

Table 1 Inductor current peak value (ipeak) selection

Do not apply a voltage between 0.7V and 2.2V to the Isel pin, as this will make the inductor current peak selection indeterminate.

Battery terminal (BAT pin) maximum voltage

The maximum voltage of the battery terminal is the highest voltage that the battery terminal (BAT pin) can reach during charging. The maximum voltage of the battery terminal is set to The voltage of the NiMH battery will drop slightly when it is nearly fully charged, so the battery voltage may not reach the required value. The maximum voltage set. If the battery voltage reaches the maximum voltage, the charging process will end immediately. This is a protection mechanism for the battery. If the battery is not connected to a charger, CN3600 will charge the output capacitor as a battery to the overvoltage protection voltage.

Battery overvoltage protection

The battery overvoltage protection unit inside CN3600 continuously monitors the BAT pin voltage. When the BAT pin voltage rises and exceeds 1.557V (typical value), When the internal P-channel MOSFET is turned off, no current flows to the battery, and the output is in high impedance state. If the charging state is maintained, When the BAT pin voltage drops below 1.496V (typical), CN3600 is released from the overvoltage protection state.

Restart the charging process.

The BAT pin voltage may reach the overvoltage protection threshold in the following three

situations: ÿ The battery is not

connected ÿ The battery load is

suddenly disconnected ÿ The charging time is set too long

When the BAT pin

voltage rises to 1.36V (typical), CN3600 enters the maintenance charge mode. The inductor current peak value decreases, as shown in Table 1. The internal maintenance charge timer starts, which determines the upper limit of the maintenance charge time. The timing time is set by the capacitor of the CT pin. When the timing ends, the entire charging cycle ends and CN3600 enters the end state. In the

maintenance charge mode, the timing time is determined by the following formula:

$$T = 12.18 \times 109 \times C2 \quad \text{(Second)}$$

in:

ÿ T is the timing time in seconds ÿ C2 is the

capacitance of capacitor C2 in Figure 1 in Farads.

The capacitance value of C2 should be greater than 100pF, otherwise the timing accuracy will be affected. If a chip ceramic capacitor is used, the capacitance value should preferably be a 1uF or 2.2uF capacitor or multiple capacitors in parallel, and the size should be

0805 or 1206. In the maintenance charge mode, when the BAT pin voltage drops to 1.339V (typical value), CN3600 enters the constant current mode and the maintenance charge timer is cleared. The maintenance charge timer will also be cleared in the battery overvoltage protection state and the chip overtemperature

protection state. Inductor current and charging

current estimation When the P-channel MOSFET inside the CN3600 is turned on, the inductor current rises. When it reaches the set peak value (ipeak), the P-channel MOSFET is turned off, and the off time is fixed to 2 microseconds (typical value), so the minimum inductor current ib is determined by the following formula:

$$ib = ipeak - \frac{VD + VBAT}{L} toff$$

In normal operation, in order to reduce electromagnetic radiation, the inductor value should be selected so that the converter operates in continuous current mode, i.e. CCM, which means that the minimum inductor current ib must be greater than zero. Even in the charging mode, the minimum inductor current ib should be greater than zero. The

waveform of the inductor current is shown in Figure 4:

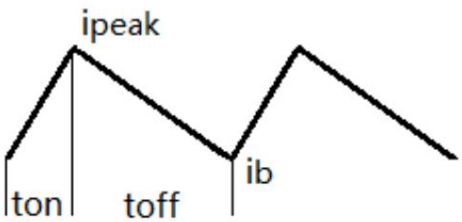


Figure 4 Inductor current waveform

The charging current, that is, the average value of the inductor current, is determined by the following formula:

$$ICH = IL = ipeak - \frac{VD + VBAT}{2L} * \frac{2(VD + VBAT) + VIN}{VIN} toff$$

In the above two formulas:

ipeak is the peak value of the inductor current, as shown in Table 1, in amperes.

VD is the forward voltage drop of the diode, in volts

VBAT is the battery voltage in volts

VIN is the input voltage in volts

L is the inductance value of the inductor L in Figure 1, in

Henrys. toff is the turn-off time of the P-channel MOSFET, typically 2 x 10–6 (seconds).

Calculating the Switching

Frequency In the typical application circuit shown in Figure 1, the on-time of the CN3600 internal P-channel MOSFET is:

$$ton = \frac{V_{BAT}+V_D}{VIN - V_{BAT} - V_D}\ toff$$

The turn-off time of the internal P-channel MOSFET is 2 microseconds (typical). So the

switching frequency of CN3600 is:

$$f_{sw} = \frac{1}{ton + toff}$$

It can be seen that the switching frequency is related to the input voltage and

the battery voltage.

Charging ends in the maintenance charging mode. If the timing ends or the BAT pin voltage reaches the set maximum voltage (typical value 1.46V), the entire charging process ends, the P-channel MOSFET inside the chip is turned off, and no current flows to the battery. Recharging is in the end

of charging

state. When the BAT pin voltage drops to the typical value of 1.339V, CN3600 enters the constant current charging mode and restarts the charging cycle. Inductor selection In order to reduce

electromagnetic

radiation, the inductor value should be selected so that the converter operates in continuous current mode (CCM) under any circumstances. Especially in the maintenance charging mode, the inductor current peak is small, so special attention should be paid. Table

2 lists the recommended inductor values:

condition	Inductance
Isel is always high	value 10uH or 15uH
Isel is low level	15uH or 22uH

Table 2 Recommended inductance values

The saturation current of the inductor should be greater

than 1.5A. Diode

selection In the circuit shown in Figure 1, diode D1 is used to prevent current from flowing back from the battery. In order to achieve higher conversion efficiency, the forward voltage of the diode should be as small as possible. Schottky diode is a better choice. The rated forward current of the diode should be greater than 1.5A. Input filter capacitor

A chip ceramic filter

capacitor of at least 4.7 microfarads needs to be connected between the power input and ground (C1 in Figure 1). If the output impedance of the input power supply is relatively large, or the input power connection wire is relatively long, the capacitance value should be increased accordingly; the withstand voltage of the capacitor should be higher than the maximum input voltage. Generally, the input capacitance value is between 4.7uF and 22uF, and has a relatively low impedance at a frequency of 1MHz. It is recommended to use X5R or X7R chip ceramic capacitors with relatively low series equivalent

resistance (ESR). Output

filter capacitor A filter capacitor (Co in Figure 1) is required between the positive electrode of the battery and ground. This capacitor also provides energy to the battery during the internal P-channel

MOSFET shutdown period. Usually, a 10uF~22uF capacitor can meet the requirements, and the ESR of the output filter capacitor should be as small as possible. It is recommended to use a series equivalent re

(ESR) is relatively low X5R or X7R chip ceramic capacitors. Chip over-

temperature protection

CN3600 has chip over-temperature protection function. When the chip junction temperature exceeds 145 degrees, the internal P-channel MOSFET is turned off and no energy is transferred to the battery. When the junction temperature drops below 124 degrees, CN3600 resumes

normal operation. In the chip over-temperature protection state, the charge timer is kept paused and the pin outputs high impedance.

Battery not connected If

the battery is not connected to the charger, CN3600 charges the output capacitor as a battery. The BAT pin voltage is quickly charged to the overvoltage protection threshold, and then the BAT pin voltage is slowly discharged to the overvoltage protection release threshold by the current consumed by the internal feedback resistor, and then quickly charged to the overvoltage protection threshold, and so on, forming a sawtooth

wave at the BAT pin. Open drain status indication output

CN3600 provides two open-drain status indication outputs: and. In constant current charging mode and maintenance charging mode, the pin is pulled to a low level by the internal switch, and the pin outputs a high impedance state in other states. In the charging end state, the pin is pulled to a low level by the internal switch, and the pin outputs a high impedance state in other states. If CN3600 is in the chip over-temperature protection or battery over-voltage protection state, the output is a high impedance state. When the battery is not connected to the charger, the pin and the pin output a high impedance state. About the input power

adaptive function

The input voltage range of CN3600 is between 2.7V and 6.5V. When the load capacity of the input power supply is less than the input current designed by CN3600, the input voltage will be controlled to a minimum of 2.68V (typical value) to adapt to the load capacity of the input power supply. In the input power adaptive mode, the input voltage may drop to 2.68V (typical value), so it is necessary to ensure that the selected MOS transistor can be fully turned on at around 2.4V. This function allows CN3600 to be powered by a solar panel. Design process In order to determine the component parameters in the circuit shown in

Figure 1, the following design process can be used: (1) According to Table 2, select the

inductor value. (2)

Determine the constant current charging current and the maintenance charging current based on the battery capacity and

charging time requirements. By connecting the Isel pin to a

high voltage

The charging current is determined by selecting two levels of inductor current peak value at a flat or low level. (3)

Determine the maintenance charging timing. According to

experience, at least 55% of the battery capacity should be replenished in the maintenance charging mode to ensure that the battery is fully charged. Assuming that the battery capacity is C, the maintenance charging timing is: T = 0.55C/ICH , where ICH is the

charging current in the

maintenance charging mode. It should be pointed out that the energy required to

be replenished in the maintenance charging mode is related to factors such as the internal resistance of the battery and the parasitic resistance of the battery connection line. Therefore, the accurate maintenance charging timing should be determined through experiments under specific application conditions, rather than just based on the above empirical data.

(4) Determine the capacitance value of timing capacitor C2 according to the timing time. Timing

time T = 12.18 x 109 x C2 (Second)

(5) Determine the input filter capacitor value based on the input power characteristics, input power wire length, input current and other factors. (6) Select a diode. Schottky diodes are best. (7) Select an output filter capacitor. Generally, 10uF to 22uF chip ceramic

capacitors can meet the requirements.

PCB Design Considerations A

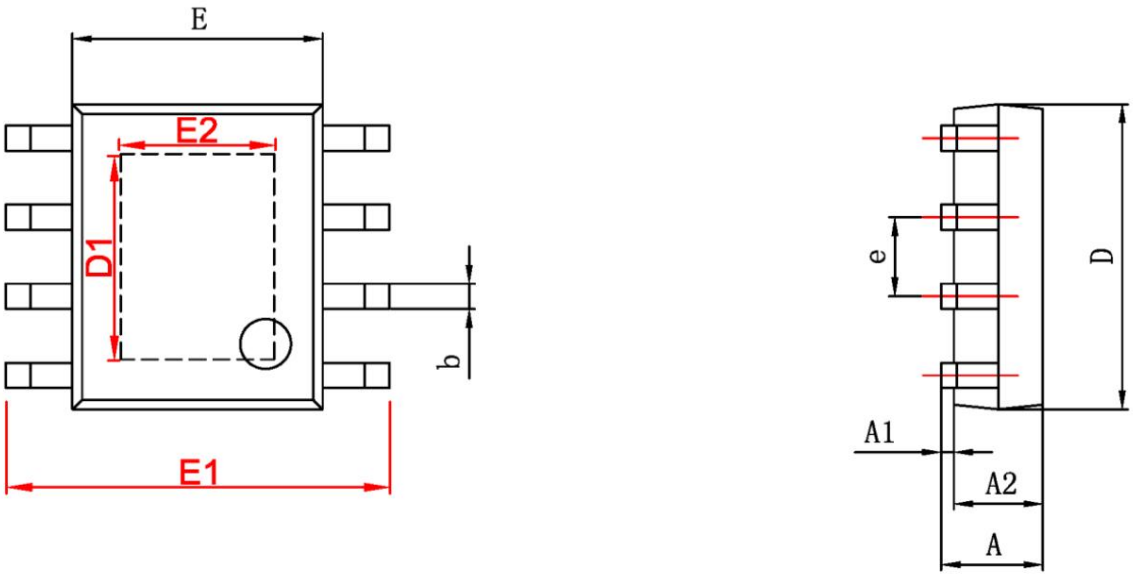
well-designed PCB is very important for the efficiency and performance of the converter. The following three suggestions are important for PCB design. ÿ Use a double-layer PCB. ÿ The output capacitor ground terminal, the

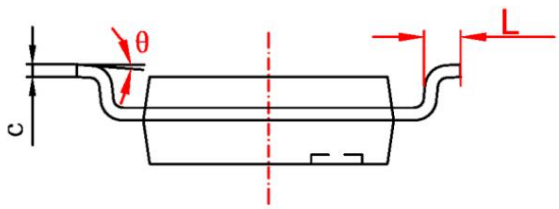
GND pin of CN3600 is connected to the ground terminal of the input capacitor through the same copper sheet, and then connected together

To the input power ground terminal (system ground). The copper connecting these nodes should be as wide as possible.

ÿ To reduce electromagnetic radiation, the copper connecting the diode, inductor, input capacitor and output capacitor should be as short as possible and wide enough.

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°