Four segment indicator, single-chip Power Bank dedicated IC

■ General Description

LN1001 includes a programmable high efficiency BUCK charger, four LED battery indicator , a Torch LED driver , a high efficiency Boost converter, and an overdischarge protector. It is suitable for single-cell lithium -ion / lithium polymer battery charge and discharge management, and can be widely used in power bank, handheld devices, PDA, smart phones and so on.

It integrates high efficiency synchronous BUCK battery charge management , the maximum charging current of up to 2A ; the integrated boost DC / DC can output the maximum discharge current reaches 1.5A , and intelligent judgments load insertion and removal , automatic boost and automatic shutdown; the integrated battery detection and 4 -segment display , both in the state of charge or discharge , can effectively indicate the current battery remaining power.

By a unique key , it can easily control the boost switch start and Torch On/off .

Torch LED can output maximum 50mA of current. LN1001 also integrates a battery temperature detection , low battery voltage protection, output over current / over voltage / short circuit protection circuit to ensure that chip and system security.

■ Applications

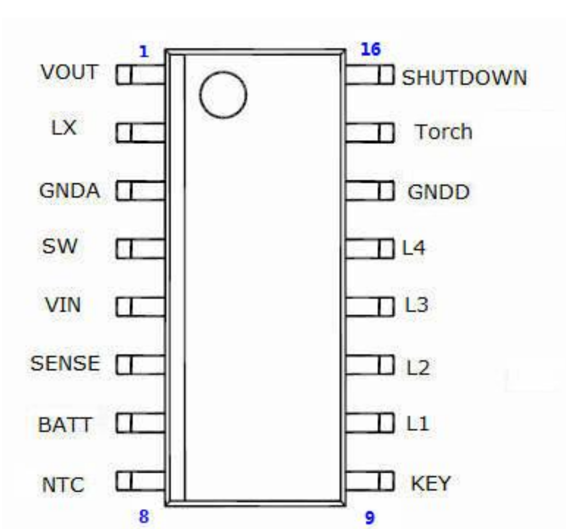
- Single-chip Power Bank solution
- Single-cell lithium-ion / lithium polymer battery charger
- Fixed 5V Boost Coverter

■ Features

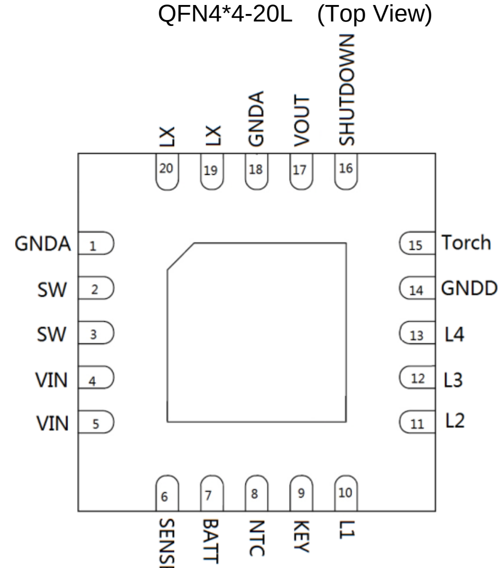
- One Key Control
- 1.5A charge current
- 2A discharge current
- 50mA Torch application integration
- Automatically start when the device is plugged into power bank(need other circuits)
- Automatically shut down when device is full or be plugged out 16 seconds
- 4 segment battery indicator
- Low standby power consumption
- Automatic shut down when Battery voltage is lower than 3.1V

■ Package

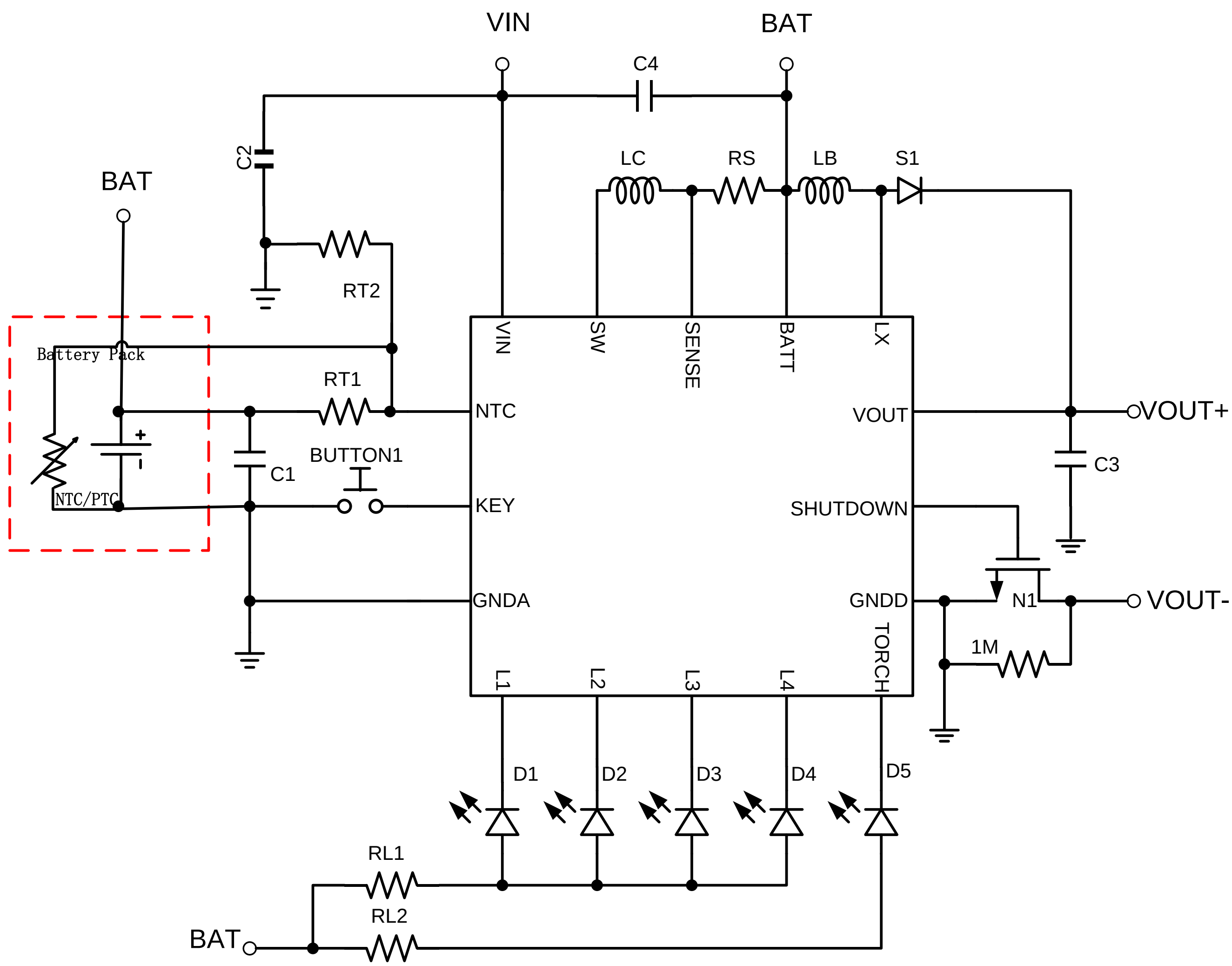
SOP16



QFN4*4-20L (Top View)



■ Typical Application Circuit



Note: L1 is the lowest indicator, and L1 is the reference of L2~L4, it must connect to a LED.

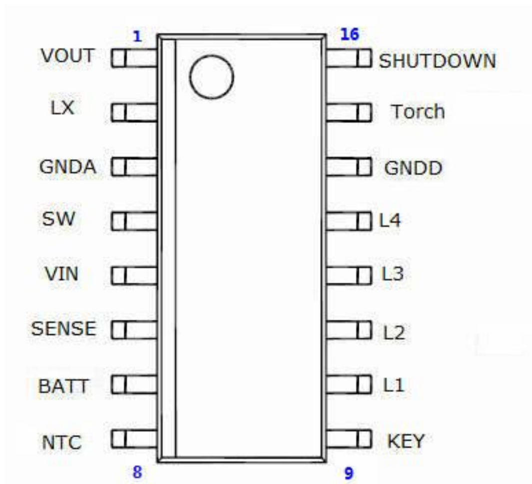
■ Ordering Information

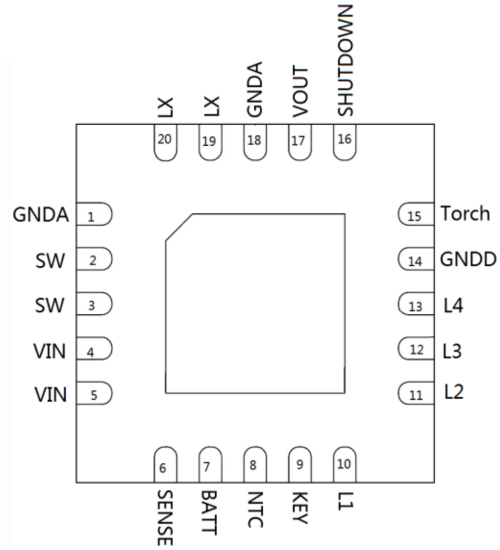
LN1001 ①②-③

Designator	Symbol	Description
①	S	SOP-8
	Q	QFN4*4-20L
②	R	Standard Tape
	L	Reverse Tape
③	G	Green Package

Note: Reverse Tape and other packages to be customized, please contact our sales department.

■ Pin Assignment

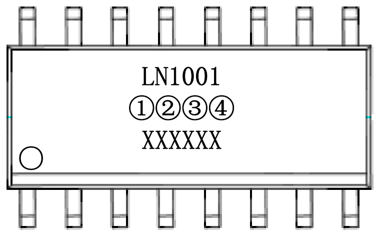


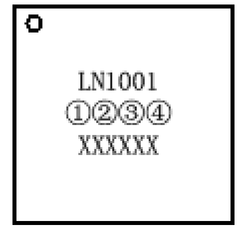


SOP Pin Number	QFN Pin Number	Pin Name	Function Description
1	17	VOUT	Boost output port,5V
2	19，20	LX	Boost inductor port
3	18，1	GNDA	Analog ground
4	2，3	SW	Inductive charger port
5	4，5	VIN	Charger power input port
6	6	SENSE	Charger current detection port
7	7	BATT	Battery access terminal
8	8	NTC	Battery temperature detection port , an external NTC resistor
9	9	KEY	Key input port , built-in pull-up resistor
10	10	L1	Battery indicator 1, output port , constant current 3mA
11	11	L2	Battery indicator 2 , output ports , constant current 3mA
12	12	L3	Battery indicator 3 , output ports , constant current 3mA
13	13	L4	Battery indicator 4 , output ports , constant current 3mA
14	14	GNDD	Digital Ground
15	15	Torch	LED Torch output ports, 50mA max.
16	16	SHUTDOWN	Load path control port

Marking Rule

- **Package Type** SOP16 QFN20

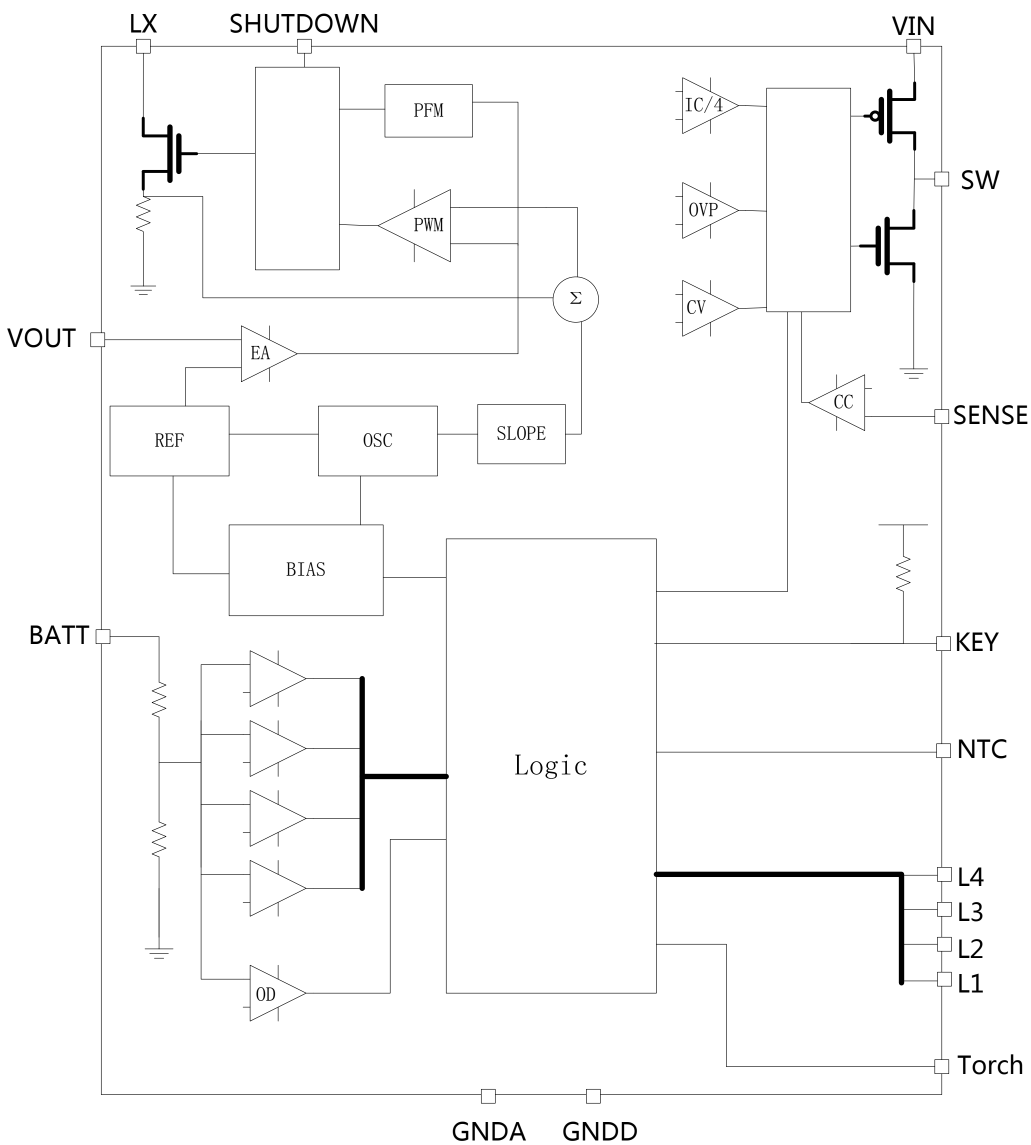




①②③④Representatives and internal processes Edition DOI

XXXXXX Represents production lot

Block Diagram



■ Absolute Maximum Ratings

Parameter	Symbol	Maximum Rating	Unit
Input Voltage	VIN	-0.3-6.5	V
VBATT	VBAT	-0.3-6.5	
Output Voltage	VOUT	-0.3-6.5	
Other terminal voltage	VOTHERS	-0.3-6.5	
LX switch current	ILX	5	A
SW switching current	ISW	±2.5	A
Operating temperature range	T_{OP}	-45-85	℃
Lead Soldering Temperature (10 seconds)	T_{LEAD}	300	
Lead Soldering Temperature (10 seconds)	V_{ESD}	4000	V

Note: Absolute maximum ratings are under any conditions cannot exceed the rating. In case exceed this rating; the product could suffer physical damage

■ Electrical Characteristics

Test Condition: VBATT=3.6V，VOUT=5V，VIN=5V，RS=0.05Ω (Ta=25 ℃ Unless Otherwise Specified)

Parameter	Symbol	Conditions	Min	Type	Max	Unit
Key end turn-on voltage	V_{KEY}	VBATT=3.6V	-	-	1.2	V
Key end of the pull-up resistor	R_{KEY}			500K		Ω
NTC temperature shutdown voltage	V_{HOT}		1.57	1.67	1.77	V
NTC Low Voltage Shutdown	V_{COLD}		3.23	3.33	3.43	V
Standby Current	$I_{STANDBY}$		-	-	1	uA
BOOST DC-DC parameters						
Input Voltage	V_{BATT}	IOUT=1A	3.2	-	5	V
Output Voltage	V_{OUT}	IOUT=1A	4.9	5.0	5.1	
Shutdown Current	I_{OFF}		-	0.01	1	μA
No Load Current	I_C	VBATT=3.6V，VOUT=5V	-	200	-	μA
Switching frequency	FS	IOUT=2A	1.25	1.5	1.75	MHz
Switching frequency	D_{MAX}	VBATT=3.6V	75	-	-	%
Power tube resistance	R	VBATT=3.6V，ISW=2A	-	65	100	mΩ
Power tube resistance	I_{LX}	VBATT=4.2V	3.5	4.5	5	A
Linear adjustment degree	ΔV_{LINE}	IOUT=1A，V_{BATT}=3.2V to 4.5V	-	0.2	-	%
Load Regulation degrees	ΔV_{LOAD}	VBATT=3.6V，IOUT=10mA to2A	-	0.22	-	%
Load Regulation degrees	T_{SHD}	VBATT=3.6V，IOUT=100mA	143	153	163	℃
Thermal Shutdown Hysteresis	ΔT_{SHD}	VBATT=3.6V，IOUT=100mA	20	25	30	℃

Parameter	Symbol	Conditions	Min	Type	Max	Unit
Automatic Shutdown Determine Current	$I_{SHUTDOWN}$	VBAT=4.0V	-	20	-	mA
Automatic Shutdown waiting time	$T_{SHUTDOWN}$	IOUT=0mA	-	16	-	S
Charger Electrical Parameters						
Input Voltage	V_{IN}		4.35	5	6	V
Input Current	I_Q	Standby Mode VIN<4.35V	50	60	70	µA
	I_{STB}	End of Charge	0.83	0.92	1.2	mA
Battery terminal current	I_R	reverse leakage current, VBATT>VIN	0	0.01	0.1	µA
	I_{OFF}	Remove VIN	-	-	0.1	uA
	I_B	Standby Mode(End of charge)	150	200	250	µA
Sensed pressure	V_{SENSE}	3V<VBATT<4.18V	90	100	110	mV
Constant current charging current	I_{CHARGE}	VBATT<4.18V	-	V_{SENSE}/RS	-	A
Charging up cut-off current	I_{END}	VBATT>4.2V	50	65	80	mA
Trickle Charge limit voltage	V_{TR}	VBATT Rising	2.8	2.92	3	V
Hysteresis voltage trickle charging	ΔV_{TR}		60	80	110	mV
Output control voltage	V_{FLOAT}	0℃<TA<85℃, IBAT = 40mA	4.158	4.2	4.242	V
Recharge the battery voltage	$V_{RECHARGE}$	VBATT falling	-	4.07	-	V
Hysteresis voltage battery recharge	ΔV_{REG}	VBATT - $V_{RECHARGE}$	90	130	170	mV
Oscillator Frequency	F_{OSC}	RL=100mA	1.35	1.5	1.65	MHz
Low-voltage lockout power	V_{UVLO}	VIN adjusted from low to high	4.3	4.35	4.45	V
Supply high voltage lockout	V_{INOVP}	VIN adjusted from low to high	6.4	6.5	6.6	V
Battery high voltage lockout	V_{BOVP}	Low battery voltage from VIN to adjust	4.32	4.37	4.42	V
LED Electrical parameters						
Current battery indicator	I_{LED}	VBAT=3.4V~4.2V	2.5	3	3.5	mA
Current matching	ΔI_{MATCH}	VBAT=3.6V	-	5	-	%
Torch LED current	I_{torch}	VBAT=3.2V-4.2V	-	-	50	mA

■ Operational Principle

LN1001 is an single-chip power bank solution, that integrated DC / DC charge management, DC / DC step-up, voltage sensing and power display. It complete the function integrated three or more of the original chip to the single chip. Performance, you can set the maximum charge current 2A, maximum output current of the boost can be achieved 1.5A, and shut down power consumption is almost zero (less than 1uA).

- **Button Operation:**

It is the one-touch control. In the off state, a short click Key (short press times greater than 60mS less than 2S), cause power on, display the power, and turn on the boost. After 4 seconds, shut down the power display, and L1 starts flashing (0.5Hz). L1 will always flashing when it is boosting. During the time, another short press Key, it can show the power 4 seconds once again, and the booster is not being affected.

The boost will automatically turns off, L1 blinking will stops and the device will enters the shutdown state, when the device is fully charged or the load is removed after 16 seconds.

When the battery voltage is lower than 3.5V, with a short press Key, L1 will flash explosion 4S to alert the low battery.

In the boost process, when the battery voltage is lower than 3.1V, the output will be automatically shut down to protect the battery not be over-discharged.

Long press Key (pressing time is greater than 2S), will open the Torch function, and long press Key again to turn off the Torch.

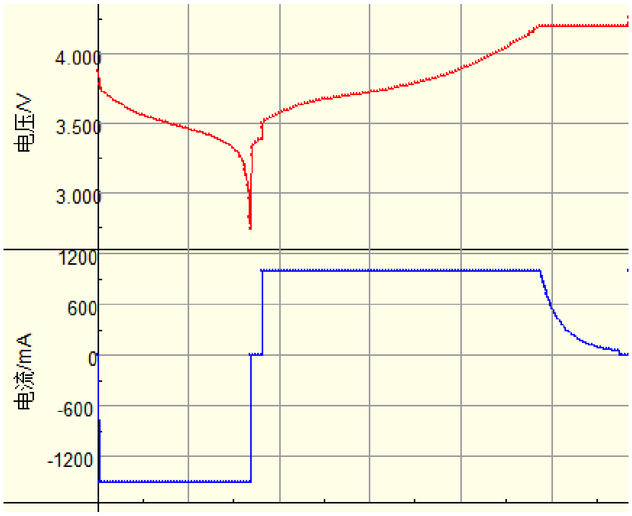
When the battery voltage is lower than 3.1V, you cannot open the Torch and output. But when the Torch has been turned on, it will not turn off when the battery voltage is too low.

During charging, short press operation is masked, but long press can turn on or turn off the Torch.

Operating Mode	Function	short press Key (60ms<Key<2S)	Long press Key (Key>2S)
Charging mode	Boost	/	/
	Power display	/	/
	Torch	/	On or Off
Boost Mode	Boost	On	/
	Power display	Show 4S	/
	Torch	/	On or Off

- **Power Display:**

When the LN1001 is during the boost or charging in, the voltage on the BATT monitored and calculated by L1-L4 shows the current consumption, and each LED represents 25% of the power. Battery charge and discharge curves, as shown



Charging, the battery indicator table below

Battery voltage	Indicator Number	Graphic（L1L2L3L4）
<3.72	L1 flashing	▲□□□
3.72-3.87	L2 flashing	■▲□□
3.87-4.02	L3 flashing	■■▲□
>4.02	L4 flashing	■■■▲
End of Charge	All light	■■■■

(■Represents a long bright, □Represents LED OFF, ▲Represents Charging Flashing, Frequence:1HZ, Pulse Width: 0.5S)

Bosting, the battery indicator table below (Short press display , four seconds and then turns off)

Battery voltage	Indicator Number	Graphic（L1L2L3L4）
>3.85	4	■■■■
3.85-3.71	3	■■■□
3.71-3.55	2	■■□□
3.55-3.43	1	■□□□
3.43-3.2	Flashing warning	◆□□□
<3.2	shut down	□□□□

(■Represents a long bright, □Represents LED OFF,◆Represent Low pressure alarm flashes, Frequence: 4HZ)

These voltage parameters for reference only , the actual difference because the battery and different production batches have voltage differences.

The power display will last 4 seconds, then L1 change to flashing , flashing period 2S, pulse width 0.25S, other LED goes off.

- **charging modes:**

Built-in constant current constant voltage battery charging management, through a current -mode PWM control DC-DC topology to achieve, the charging current is set by an external connection on both ends of the VBATT and SENSE resistor to set the chip internally by a high accuracy reference to set the charging voltage.

When the input voltage is below the UVLO level (4.35V), the chip enters SLEEP MODE, then the chip power consumption to 60μA or less. When the input voltage rises above the UVLO voltage, the charger enters charging mode, then L1-L4 shows charging blinking. If the battery voltage is lower than the trickle charge threshold voltage (2.9V), the charger enters trickle charge mode, and the trickle charge set to 25 % of the maximum charge current. When the battery voltage exceeds the trickle charge threshold, the charger enters constant current charging mode, then the charging current by the internal 100mV reference and external sense resistor to decide, calculated as follows: I_{CHARGE}=100mV/RS.

When the battery voltage is close to the target value 4.2V, the charge current of the chip begins to drop and the chip enters constant voltage charging mode LDO. When the current drops to 65mA, the chip stops charging, L1-L4 full brightness. When the battery not leave BATT terminal and the battery voltage drops to 4.07V, the chip will automatically enter RECHARGE state, and restart the charge cycle.

Once in charging mode, the boost circuit will automatically stop when the short press operation is masked, but the long press can turn on or turn off the light. Exit charge mode after entering standby mode.

- **Boost mode :**

In shutdown mode, short press Key or detect access to the load, then the boost circuit starts operating.

In boost circuit, it can achieve efficient and stable work in a wide load range, using PWM current mode and voltage mode PFM automatic switching. Building a 4.5A power switch, lithium battery can deliver up to 2A of output current, and efficiency of 90% (up 95%).

The SHUTDOWN pin with an external NMOS transistors, is to achieve the power path completely shutdown. When the chip is normal working, SHUTDOWN is high, and VOUT- used as a load. Work in the chip off or an abnormal state (such as the short-circuit protection, etc.), SHUTDOWN client will drop as low to achieve the power path completely shutdown.

SHUTDOWN end remain unconnected when it is not in use, and prohibit connecting to VBATT or GND terminal.

The external NMOS transistor with the use of SHUTDOWN function, need very little resistance RDSON, in order to ensure high efficiency and ideal load short-circuit protection.

Boost working, if detected the VIN voltage greater than 1.6V, it is considered to enter charge mode, SHUTDOWN immediately pulled low, and the output path closed. When the VIN is removed, it need to re-boost button before resuming work.

Boost after the start, if it detects the output load current is very small (less than 20mA),keeping this state for more than 16S, chips that are unloaded automatically enter standby mode, where the static power consumption is almost zero.

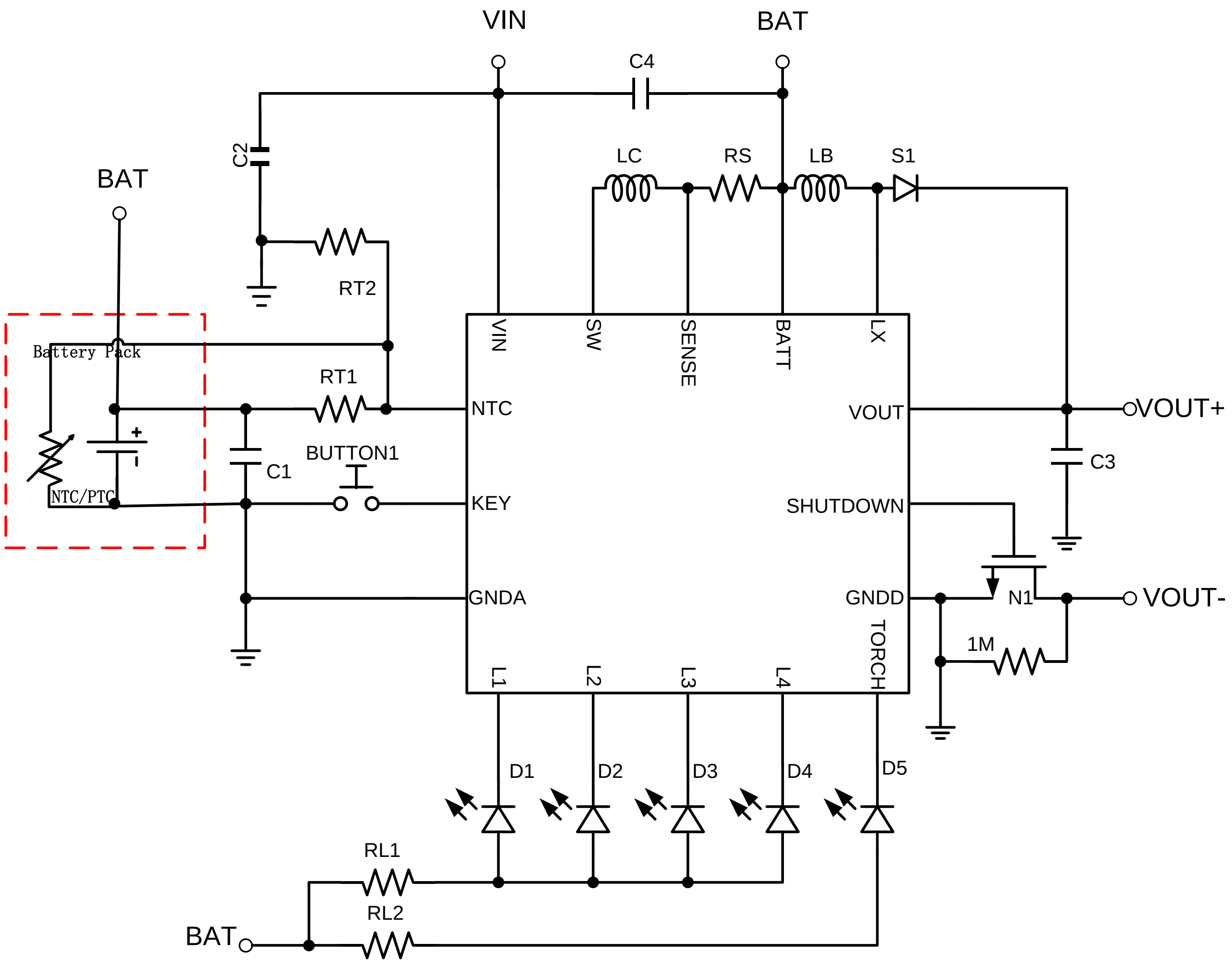
- **temperature protection:**

LN1001 built-in temperature compensation circuit, when the internal temperature reaches 100 ℃, the maximum charging current or the maximum output current will fall with increasing temperature, reducing the possibility of thermal breakdown of the chip, improving the reliability of the system on a chip. When the temperature rises to 150 ℃, the chip enters the temperature protection, cutting output or stopping charging.

The chip also comes with battery temperature detection function, and this function through the NTC side to achieve. The VBATT connect to divider resistors RT1 and RT2, and the NTC is terminated with a negative temperature coefficient thermistor of 10KΩ RNTC (MF103F338F), RT1 and RT2 according to battery temperature monitoring range and thermistor resistance values to determine.

This pin can be directly connected to GND, to shield the temperature detection function.

Application Specification



Number	Part Number	Model (reference value)	Quantity
1	U1	LN1001	1
2	S1	SK34	1
3	LB，LC	3.3uH	2
4	RS	According to the charging current custom,0.05Ω	1
5	RT1	According to the temperature range from the set, 2.54K	1
6	RT2	According to the temperature range of custom, 5.32K	1
7	C1	22uF	1
8	C2	22uF	1
9	C3	100uF	1
10	N1	MOSFET N, LN2312	1

11	D5	50mA Bright LED	1
12	D1~D4	LED lights (red / blue / green)	1
13	RL1	Limiting resistor, 75Ω	1
14	RL2	Limiting resistor , 47Ω	1
15	BUTTON1	BUTTON ， K1	1
16	C4	1uF	1

- **Choice of Components :**

1. The selection of booster circuit output capacitor C3. The selection Output Capacitor depends on the output voltage ripple. In most cases, you want to use low ESR capacitors, such as ceramics and polymers electrolytic capacitors. If you use a high- ESR capacitor,c you need to carefully review the converter frequency compensation, and in the output circuit terminal may need to add an additional capacitor.

2. Choose textures and values of inductor LB and LC. Because the inductor value affects the input and output ripple voltage and current, so the inductor selection is the key of inductive voltage converter design. Low equivalent series resistance of the inductor, the power conversion efficiency is the best. Choose the inductor saturation current rating, make it greater than the steady-state circuit inductor current peak.

3. Boost converter to choose fast forward voltage drop of the schottky rectifier diodes, so make it low power consumption and high efficiency. The average current of schottky diode rating should be greater than the maximum output current of the circuit.

4. Try to use a small internal resistance, fast switching speed of the MOSFET N, so make it low power consumption and high efficiency, and be ready to heat treatment. LN2312 for the N-channel enhancement type field effect transistor, RDSON = 27mohm @ VGS = 3.6V, can meet the conditions of use.

MOSFET N try to use a small internal resistance, fast switching speed, low power consumption and high efficiency make it, and be ready to heat treatment. LN2312 for the N-channel enhancement type field effect transistor, RDSON = 27mohm @ VGS = 3.6V, can meet the conditions of use.

5、Temperature protection divider resistor selection RT1/RT2

The VBATT connects the dividing resistors RT1 and RT2, and the NTC connects a negative temperature coefficient thermistor 10KΩ RNTC

(MF103F338F), RT1 and RT2 according to battery temperature monitoring range and thermistor resistance values to determine

Suppose the set battery temperature range TL ~ TH, (TL <TH); negative temperature coefficient thermistor (NTC). RTL is the resistance at temperature TL, and RTH is the resistance at temperature TH, RTL> RTH.

At the temperature TL , NTC V_TL the voltage is: $V\_TL = VIN \times \frac{RT2 // RTL}{RT1 + RT2 // RTL}$;

At the temperature TH , NTC voltage V_TH is: $V\_TH = VIN \times \frac{RT2 // RTH}{RT1 + RT2 // RTH}$;

By $V\_TL = \frac{2}{3} VIN$、$V\_TH = \frac{1}{3} VIN$, too $RT1 = \frac{3 \times RTL \times RTH}{2 \times (RTL - RTH)}$, $RT2 = \frac{3 \times RTL \times RTH}{RTL - 2 \times RTH}$

Similarly, if the battery using the positive temperature coefficient (PTC) thermistors, then RTH> RTL, in the formula of RT1 and RT2, the RTL and RTH can be reversed.

Derived from the above it can be seen that the subjecting set temperature range has nothing to do with supply voltage VIN. It is to do with RT1, RT2, RTL, and RTH; including RTL, RTH battery can access the relevant manuals or obtained through experimental tests.

In practical application, if only one side of the temperature characteristics of concern, such as thermal protection, it cannot RT2, RT1 can use only. Calculating R1 becomes very simple, and do not repeat them here.

For example: Select the NTC resistor 10K, RT1=2.54K, RT2=5.32K. -20 to 60 degrees to achieve a temperature range of detection.

- **PCB LAYOUT NOTES:**

1、Sampling resistance RS, and the filter capacitor C1, C2 as close IC.

2、High-current paths must be thick and wide wiring, and cabling area as small as possible .

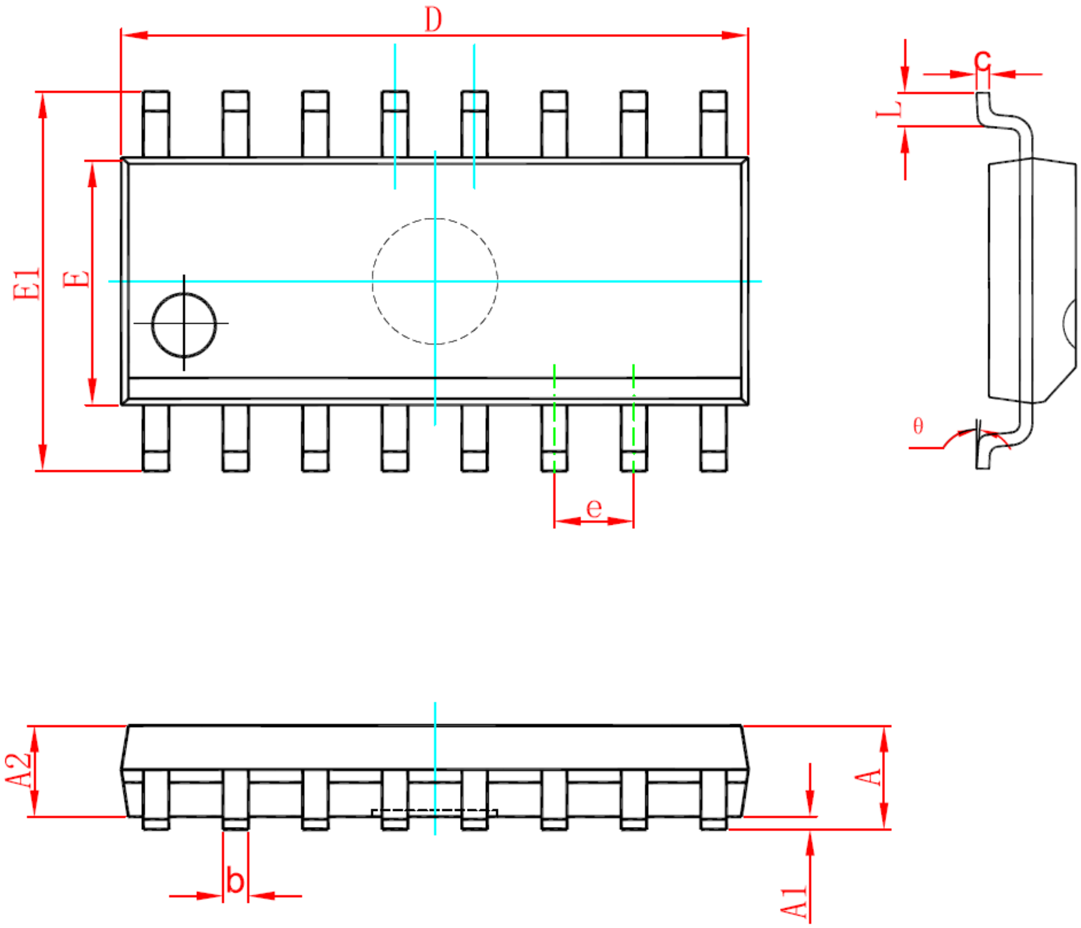
3、Distinguish GNDA and GNDD alignment , grounding must be good.

4、High-frequency switching path is not through-hole, not the bottom cloth signal line inductance.

5、Ground area is large enough, and the board should shop copper to control IC heat well.

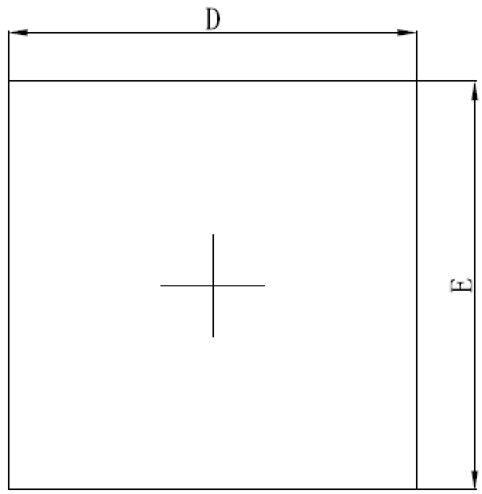
Package Information

SOP16 PACKAGE OUTLINE DIMENSIONS

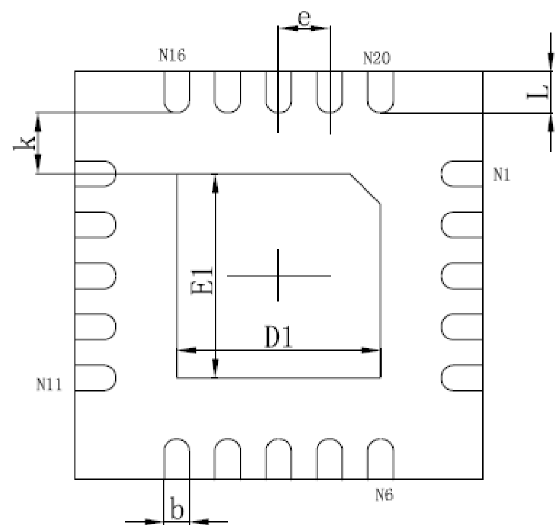


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	9.800	10.200	0.386	0.402
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

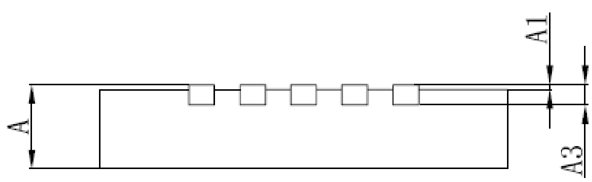
QFN4*4-20L PACKAGE OUTLINE DIMENSIONS



Top View



Bottom View



Side View

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.700/0.800	0.800/0.900	0.028/0.031	0.031/0.035
A1	0.000	0.050	0.000	0.002
A3	0.203REF.		0.008REF.	
D	3.900	4.100	0.154	0.161
E	3.900	4.100	0.154	0.161
D1	1.900	2.100	0.075	0.083
E1	1.900	2.100	0.075	0.083
k	0.200MIN.		0.008MIN.	
b	0.180	0.300	0.007	0.012
e	0.500TYP.		0.020TYP.	
L	0.300	0.500	0.012	0.020

■ Version History

Serial Number	Version Number	Modified Date	Modify content	Modifier	Approver
1	1.0	2013-6-24	First Draft	Jiang.	
2	1.1	2013-9-11	QFN	Jiang	