Boost Charging IC for 2/3 Serial Lithium Battery With 15W Fast Charge

1. Features

- **Charging**
  - ✧ Integrated 15W synchronous switch-mode boost charger
  - ✧ 94% boost charging efficiency
  - ✧ Integrated charge equalization circuit
  - ✧ Support input fast charge application, according to battery voltage application fast charge input, improve charging efficiency
  - ✧ Programmable constant voltage charging voltage by external resistor
  - ✧ The pin can be set to 2/3 series lithium battery charging
  - ✧ Programmable charging current by external resistor
  - ✧ According to the battery voltage, automatically apply for fast charging input
  - ✧ Self-regulated input current, adaptive adapter or load
  - ✧ LED for charging status indication
- **Minimal BOM**
  - ✧ Power MOSFETs integrated
  - ✧ 500kHz switching frequency, support 2.2uH inductor
- **Multiple protection, high reliability**
  - ✧ Support charging NTC temperature protection
  - ✧ Output OC, OV and Short circuit protection
  - ✧ Input voltage withstand 25V
  - ✧ ESD 4kV ability
  - ✧ Input over-voltage, under-voltage protection can be adjusted by external resistor
  - ✧ Charging timeout protection, can be adjusted by external resistor
  - ✧ IC overtemperature protection

2. Description

IP2326 is a boost charging IC for 2/3 serial lithium battery with 15W fast charge

IP2316 is highly-integrated, few peripheral devices is needed in application, delivering small PCB area and low BOM cost.

IP2326 integrate synchronous switching circuit with power FETs at 500kHz switching frequency. Maximum 15W input charge. 5V VIN, the charging efficiency is 94% when VOUT is 8V/1A, the charging efficiency is 92% when VOUT is 8V/1.5A

IP2326 has the function of input voltage limiting. The charge current is regulated automatically. Adaptive adapter load capacity

IP2326 supports external pins to set 2 or 3 series lithium battery charging

IP2326 supports an external resistor to adjust charging current, charging voltage, input under-voltage threshold, input over-voltage threshold, charging time-out threshold and other parameters

IP2326 can be based on the battery voltage, to apply for fast charging input to improve charging efficiency, shorten charging time

IP2326 integrated 2 series charge equalization circuit, can detect each battery voltage when charging, to ensure 2 battery voltage balance

IP2326 integrated NTC protection function, with NTC resistor

IP2326 is package in QFN24, 4*4mm

3. Typical Applications

- **Two-cell/three-cell Li/Li-Ion battery charging management**

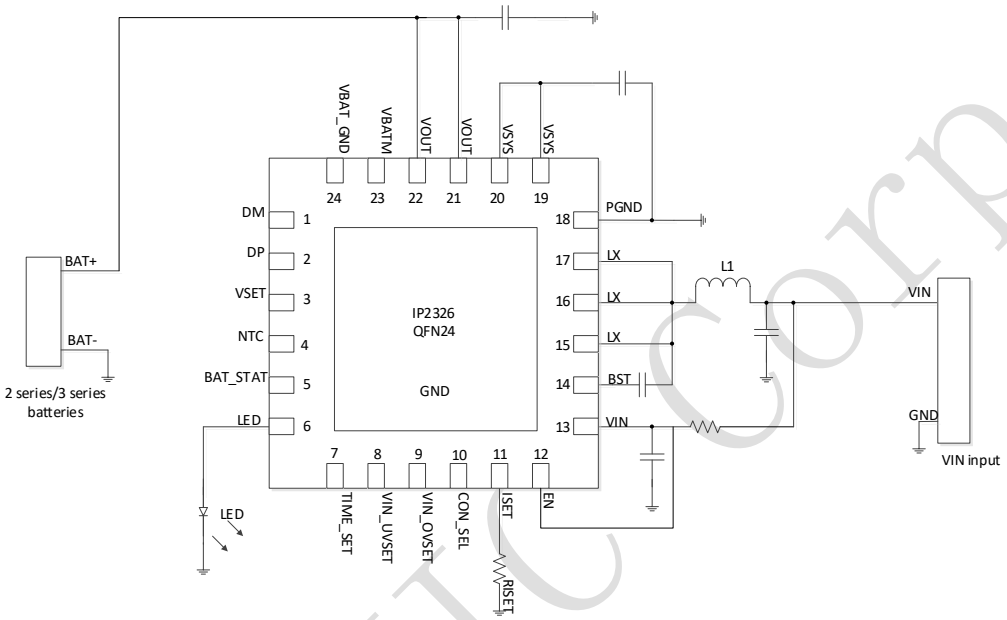


Figure 1 Simplified Application Schematic

4. Pin Configuration And Function

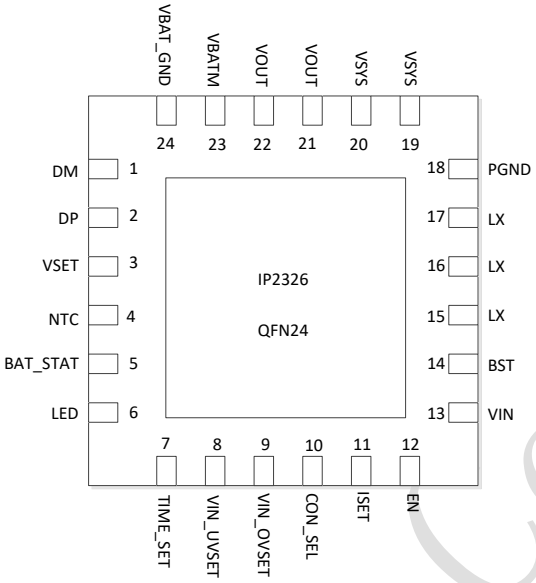


Figure 2 IP2326 Pin Assignment

Pin Name	Pin Num	Pin Description
DM	1	USB DM
DP	2	USB DP
VSET	3	Constant voltage charging voltage setting pin, can fine-tune the charging voltage
NTC	4	NTC temperature protection function with NTC resistor, output 20uA current
BAT_STAT	5	Charging output state indication, low level output when trickle charging, high level output after constant current charging
LED	6	Charging indicator LED
TIME_SET	7	Charging time-out protection setting pin
VIN_UVSET	8	Charging under-voltage threshold setting pin
VIN_OVSET	9	Charging over-voltage threshold setting pin
CON_SEL	10	Select that 2/3 series battery charging, floating select 2 series charge; select 3 series charge if it pull down to GND with a 1 kOhm resistor
ISET	11	Charging current setting pin, cannot be left floating
EN	12	Enable pin, the chip does not work after pull down to ground
VIN	13	Input power supply and check pin
BST	14	Bootstrap circuit pins with bootstrap capacitance 0.1uF placed next to BST and LX pins of the chip
LX	15、16、17	DCDC switch node, connect to external inductor
PGND	18	Power ground
VSYS	19、20	Two 22uF ceramic capacitors are placed close to the pin at the

		intermediate node of the boost output
VOUT	21、22	Boost output pin, connect battery positive
VBATM	23	Charging equalization function, Middle Battery Voltage Detection Pin, it should be left floating when doesn't use
VBAT_GND	24	Charge equalization function, detecting whether the battery pull down to ground pin, it should be left floating when doesn't use
GND	EPAD	Power ground

5. Absolute Maximum Ratings

Parameters	Symbol	Value	Unit
Input Voltage Range	V_{IN}	-0.3 ~ 25	**V**
VOUT、VSYS、LX、VBATM、DM、DP Voltage Range	V	-0.3 ~ 20	**V**
BST Voltage Range	V_{BST}	-0.3 ~ V_{LX} +8	**V**
Junction Temperature Range	T_J	-40 ~ 150	℃
Storage Temperature Range	Tstg	-60 ~ 150	℃
Junction Temperature(junction to ambient)	θ_{JA}	60	**℃/W**
Human Body Model (HBM)	ESD	4	**KV**

*Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to Absolute Maximum Rated conditions for extended periods may affect device reliability.
*Voltages are referenced to GND unless otherwise noted.

6. Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input Voltage	V_{IN}	4.5	5	9.5	V
Charge Current	I	0		1.5	A

*Devices' performance cannot be guaranteed when working beyond those Recommended Operating Conditions.

7. Electrical Characteristics

Unless otherwise specified, TA = 25°C, L = 2.2uH, VIN = 5V, VOUT = 7.4V

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
2 series charging (CON_SEL left floating)						
Input Voltage	V_{IN}		4.5	5	-	V
Input under-voltage threshold	V_{IN-UV}	R_{UV}=NC	4.55	4.65	4.75	V
		R_{UV}=120K	4.35	4.45	4.55	V
		R_{UV}=68K	4.25	4.35	4.45	V
		R_{UV}=1K	4.15	4.25	4.35	V

Input over-voltage threshold	V_{IN-OV}	R_{OV}=NC	8.6	8.75	8.9	V
		R_{OV}=120K	8.3	8.4	8.5	V
		R_{OV}=68K	7.9	8	8.1	V
		R_{OV}=1K，disable input over-voltage	-	-	-	V
Input Current	I_{VIN}	EN=1，V_{IN}=5V，V_{OUT}=NC, NO LED	10	20	30	mA
Standby Current	$I_{standby-BAT}$	EN=0，V_{IN}=0，V_{OUT} =7.4V		0.7	1	uA
		EN=0，V_{IN}=5V，V_{OUT} =7.4V		2.5	3	uA
Charge Target Voltage	V_{TRGT}	R_{VSET}=NC	8.3	8.4	8.5	V
		R_{VSET}=120K	8.2	8.3	8.4	V
		R_{VSET}=68K	8.1	8.2	8.3	V
		R_{VSET}=1K	8.0	8.1	8.2	V
Charge Current	I_{CHRG}	Constant output current, 2 series charging V_{OUT}=7.6V，R_{ISET}=90K	0.9	1.0	1.1	A
Trickle Charge Current	I_{TRKL}	VIN=5V，VOUT<3.6V	-	50	70	mA
		VIN=5V，3.6V<=VOUT<6V，R_{ISET}=90K	-	100	150	mA
Charge Cut-off Current	I_{STOP}			200	300	mA
3 series charging (CON_SEL pull down to ground)						
Input Voltage	V_{IN}		4. 5	5	8.75	V
Input under-voltage threshold	V_{IN-UV}	R_{UV}=NC	4.55	4.65	4.75	V
		R_{UV}=120K	4.35	4.45	4.55	V
		R_{UV}=68K	4.25	4.35	4.45	V
		R_{UV}=1K	4.15	4.25	4.35	V
Input over-voltage threshold	V_{IN-OV}	R_{OV}=NC	11	11.25	11.5	V
		R_{OV}=120K	10.6	10.8	11	V
		R_{OV}=68K	10.1	10.3	10.5	V
		R_{OV}=1K，disable input over-voltage	-	-	-	V
Input Current	I_{VIN}	EN=1，V_{IN}=5V，V_{OUT}=NC, NO LED	20	30	40	mA
Standby Current	$I_{standby-BAT}$	EN=0，V_{IN}=0，V_{OUT} =10.8V		1.5	2.5	uA
		EN=0，V_{IN}=5V，V_{OUT} =10.8V		3	4	uA
Charge Target Voltage	V_{TRGT}	R_{VSET}=NC	12.5	12.6	12.7	V

		R_{VSET}=120K	12.4	12.5	12.6	V
		R_{VSET}=68K	12.3	12.4	12.5	V
		R_{VSET}=1K	12.2	12.3	12.4	V
Charge Current	I_{CHRG}	Constant output current, 3 series charging V_{OUT}=10.8V ， R_{ISET}=90K	0.9	1.0	1.1	A
Trickle Charge Current	I_{TRKL}	VIN=5V，VOUT<3.6V	-	50	70	mA
		VIN=5V ， 3.6V<=VOUT<6V ， R_{ISET}=90K	-	100	150	mA
Charge Cut-off Current	I_{STOP}			200	300	mA
Control System						
LED Drive Current	I_{Led}	VIN=5V			5	mA
NTC Pin Current	I_{NTC}		19	20	21	uA
EN High Level	EN_{INH}		1.4		VIN	V
EN Low Level	EN_{INL}		0		1.2	V
Thermal Shutdown Temperature	T_{OTP-H}	Rising Threshold	125	135	145	℃
Thermal Shutdown recovery Temperature	T_{OTP-H}	Falling Threshold	100	110	120	℃

8. IP Comparison Table

Type name	Function
IP2326	Standard, two-cell/3-cell charge, support for VSET、ISET、UVSET、etc
IP2326_8V8	Base on IP2326 standard, the constant voltage charging voltage is increased by 0.4V
IP2326_NPD	Charging current setting lower than 700mA

9. Function Description

9.1 Functional Block Diagram

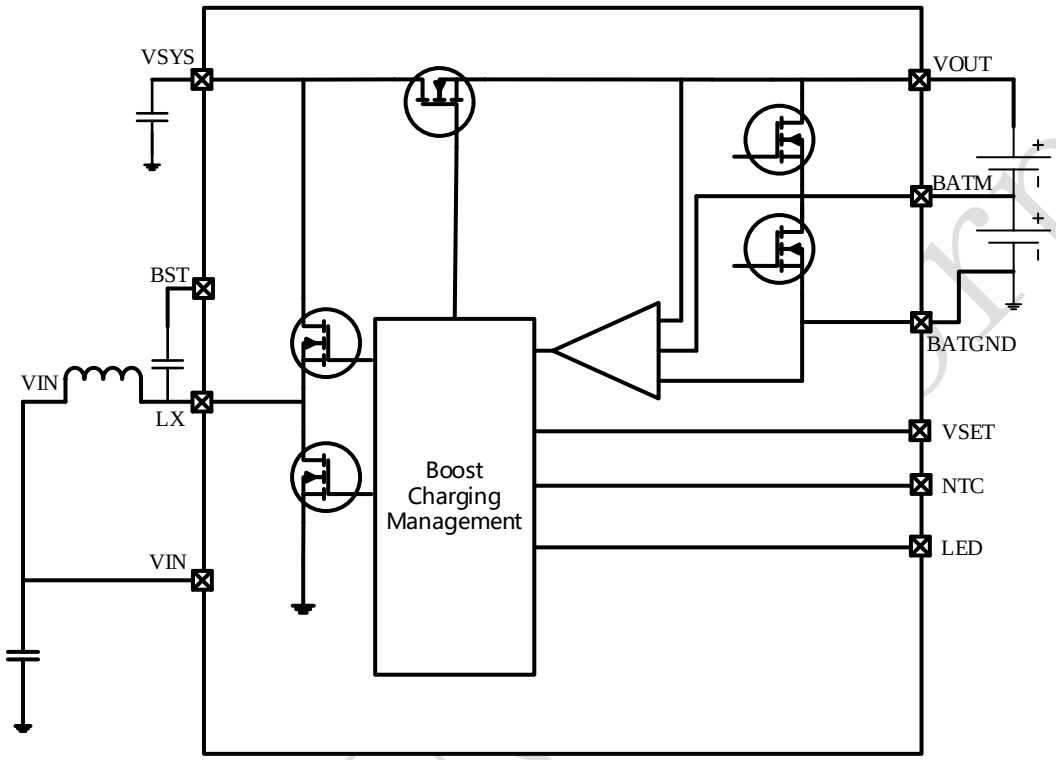


Figure 3 IP2326 Functional Block Diagram

9.2 Boost Charge

IP2326 integrated a synchronous boost charger with 500kHz switching frequency, the output boost charging for two-cell/three-cell Li/Li-Ion battery. When it is 2 series charging ,5V VIN, the efficiency is 94% at 8.0V/1A output. 9V VIN, the efficiency is 94% at 12V/1A output.

When Vin=5V and Iout=1/1.3/1.5/1.8/2A, the charging efficiency curve of 2-series batteryis as follows:

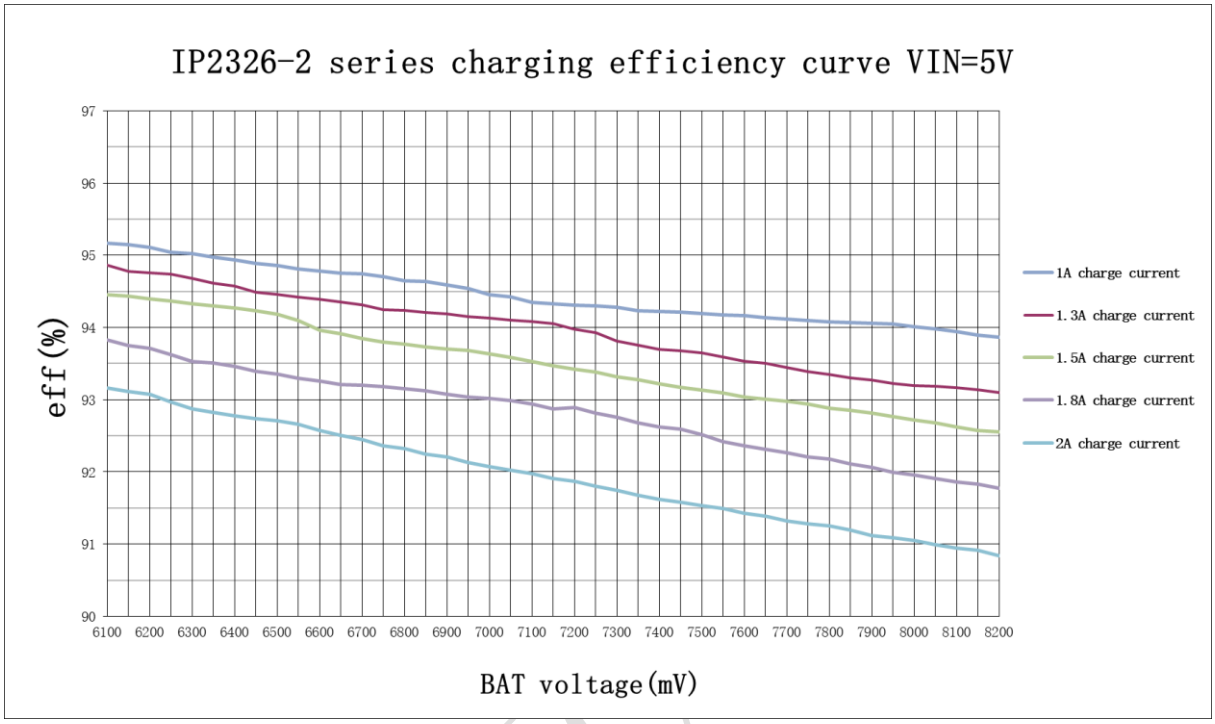


Figure 4 Charging efficiency curve of Vin=5V 2-series battery

When Vin=5V and Iout=0.75/1/1.2A, the charging efficiency curve 3-series batteries as follows:

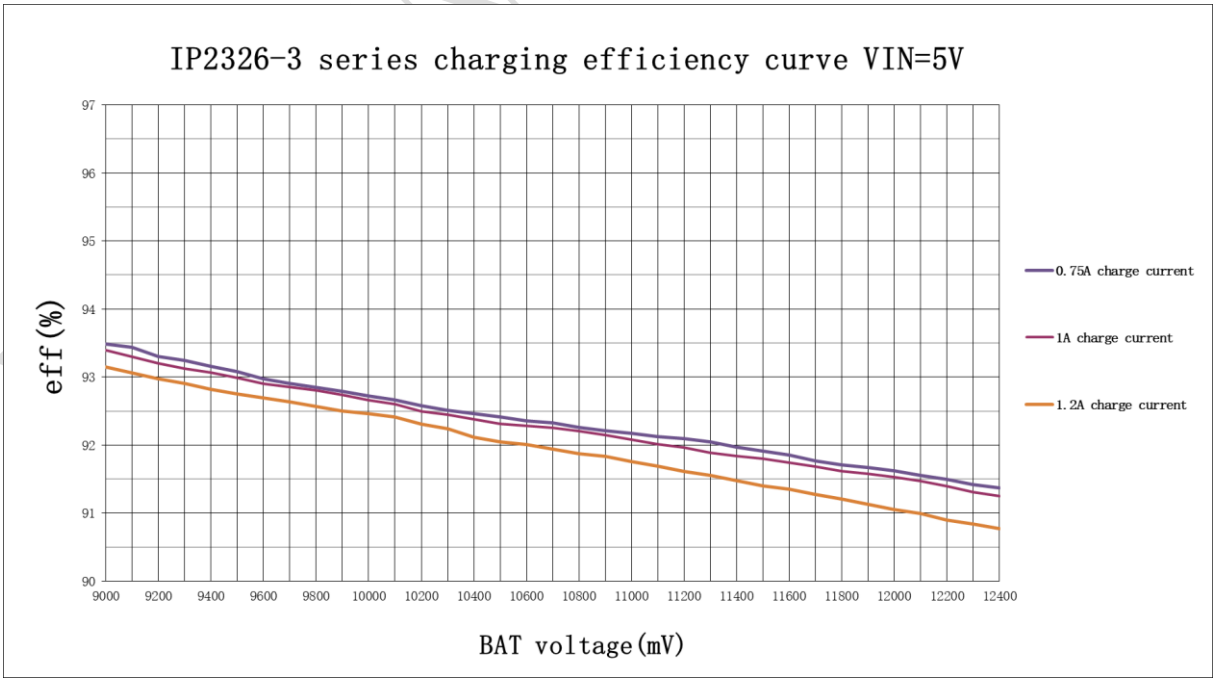


Figure 5 Charging efficiency curve of Vin=5V 3-series battery

When the charging current = 1A and Vin=5/7/9V, the discharge efficiency curves of the 3-series battery as follows:

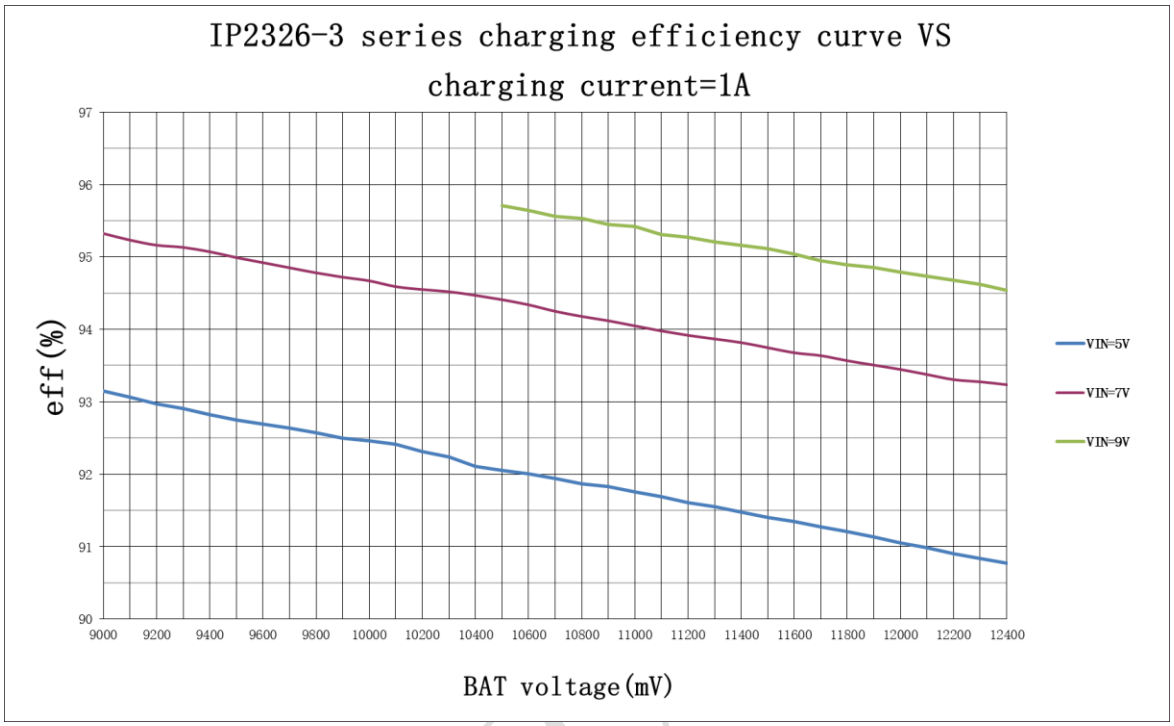


Figure 6 Charging current=1A, discharge efficiency curve of 3-series battery

When the charging current = 1.2A and Vin=5/7/9V, the discharge efficiency curves of the 3-series battery as follows:

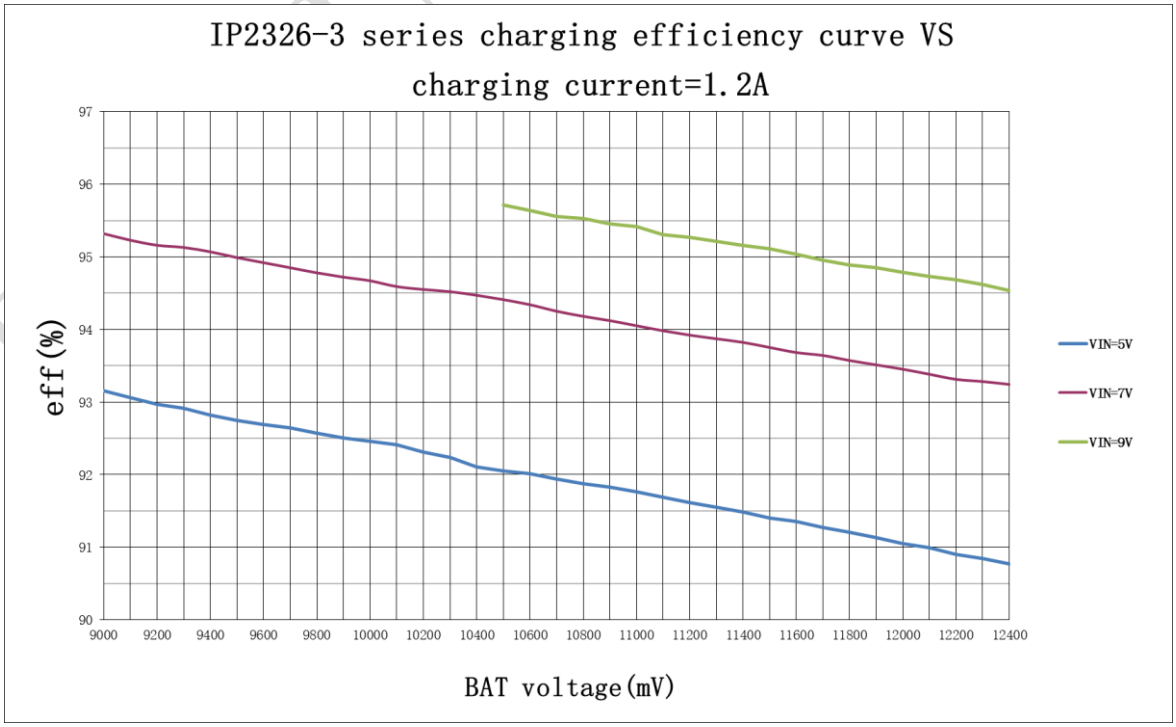


Figure 7 Charging current=1.2A, discharge efficiency curve of 3-series battery

9.3 2/3 Series Charging Set

IP2326 CON_SEL pin can be used to choose between 2 series charging or 3 series charging:

When CON_SEL pin is suspended, select 2 series charging;

When CON_SEL is pull down to GND with 1kOhm resistor, select 3 series charging;

9.4 Charge Process

IP2326 deploy the complete CC (Constant Current)/CV (Constant Voltage) charging mode.

Configured for 2 series charging:

When the batteries' voltage is lower than 3.7V, charge the batteries in 50mA current.

When the batteries' voltage is between 3.7V and 6V, charge the batteries in 100mA current

When the batteries' voltage is above 6V, the charging current will be I_{CC}.

When the batteries' voltage reaches near 8.4V, the system will enter CV mode.

When the charging process terminated after batteries are fully charged, and the input persists , if the battery voltage is less than 8V, the charging process will be start again.

Configured for 3 series charging:

When the batteries' voltage is lower than 3.7V, charge the batteries in 50mA current.

When the batteries' voltage is between 3.7V and 9V, charge the batteries in 100mA current

When the batteries' voltage is above 9V, the charging current will be I_{CC}.

When the batteries' voltage reaches near 12.6V, the system will enter CV mode.

When the charging process terminated after batteries are fully charged, and the input persists , if the battery voltage is less than 12V, the charging process will be start again.

In the CV mode, the system will pause the charging after 30s if the charging current is less than 200mA. Detect whether the battery voltage is higher than the stop charging voltage, if it is higher, stop charging, if it is lower, continue charging.

9.5 Input Fast Charge Application

IP2326 can be based on the current battery voltage, through DP/DM to the input application of fast charging voltage;

Configured for 2 series charging:

When the batteries' voltage is lower than 6.2V, don't apply for fast charge, just 5V input charge;

When the batteries' voltage is between 6.2V and 6.8V, Will attempt to apply for a 5.4V input fast charge;

When the batteries' voltage is between 6.8V and 7.8V, Will attempt to apply for a 6V input fast charge;

When the batteries' voltage is more than 7.8V, Will attempt to apply for a 7V input fast charge;

Configured for 3 series charging:

When the batteries' voltage is lower than 9V, don't apply for fast charge, just 5V input charge;

When the batteries' voltage is between 9V and 10.5V, Will attempt to apply for a 7V input fast charge;

When the batteries' voltage is more than 10.5V, Will attempt to apply for a 9V input fast charge;

If it can't successfully apply for fast charge input, it will be charged with 5V input at all times

9.6 Charge Protection

IP2326 has full protection functions, integrated output over-current, input under-voltage, over-voltage, over-temperature and other protection functions to ensure the system stable and reliable work.

IP2326 has an input voltage stabilizing loop for VIN. When the input voltage is close to under-voltage threshold set by R_{UV}, the charging current will be lowered automatically to ensure the input voltage is stable near the input under-voltage threshold and that the adapter will not fail.

IP2326 integrated input over-voltage protection function, when detected input voltage is more than the over-voltage threshold set by R_{OV}, it will stop charging.

IP2326 integrated NTC function, with NTC resistor, can detect the battery temperature, when it is too high or too low, the system can stop charging.

IP2326 integrated over-temperature protection function, when the chip internal temperature is detected more than 135℃, the system will be forced to stop charging.

IP2326 integrated charging over-time protection function, when the time of charging is more than the maximum time set by $R_{OT,}$ the system will be forced to stop charging.

9.7 Charge Equalization Function

When the equalization function is not used, the relevant pins (pins 23 and 24) should be suspended

During the charging process, IP2326 will detect the voltage of the two batteries, when any one battery voltage reaches VCBON, it will turn on the corresponding equalizer MOS in IP2326 to reduce the charging current of this battery.

Equalization close conditions:

1、 The voltage both two batteries is higher than the equilibrium open voltage VCBON.

2、 Out of normal charging state (such as NTC protection, input over-voltage, battery charged, etc).

The equilibrium current can be set by adjusting the RCB, which is consumed in the form of heat in the internal

Equilibrium MOS and RCB, so the equilibrium current setting should be less than 40mA (RCB should be greater than 100 Ohm), ICB=VCB/RCB;

The equilibrium opening voltage of reference VCBON=4.1V;

9.8 Charging Voltage Set

IP2326 support VSET pin external resistor RVSET, to set constant voltage charging voltage.

RVSET sets constant voltage charging voltage

RVSET	2-string battery constant voltage charging voltage	3-string battery constant voltage charging voltage
1k	8.1V	12.3V
68k	8.2V	12.4V
120k	8.3V	12.5V
NC	8.4V	12.6V

9.9 Charging Current Set

IP2326 support ISET pin external resistor RISET, to set constant current charging current, set the current is the maximum battery charging current.

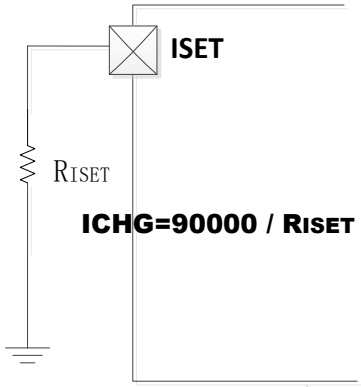


Figure 8 ISET peripheral circuit diagram

Typical current recommended resistor:

RISET sets the charge current at the battery
ICHG=90000/RISET

RISET	Charge current
120k	0.75A
90k	1A
75k	1.2A
60k	1.5A

Note: For charging current less than 700mA, please use the IP2326_NPD.

9.10 Input Under-voltage Threshold Set

IP2326 supports VIN_UVSET pin external resistor RUV to set input the under-voltage threshold

RUV sets the input under-voltage threshold

RUV	Input under-voltage threshold
1k	4.25V
68k	4.35V
120k	4.45V
NC	4.65V

IP2326 VIN input loop automatically lowers the charging current when it detects that the input voltage is close to the set input under-voltage threshold, ensuring that the input voltage is stable near the input undervoltage threshold and that the adapter is not failed

9.11 Input Over-voltage Threshold Set

IP2326 supports VIN_OVSET pin external resistor ROV to set input the over-voltage threshold

ROV sets the input over-voltage threshold

Rov	2 series charge Input over-voltage threshold	3 series charge Input over-voltage threshold
NC	8.75V	11.25V
120K	8.4V	10.8V
68K	8V	10.3V
1K	disable, no over-voltage	

9.12 Charge Timeout Time Set

IP2326 supports TIME_SET pin external resistor ROT to set the input charge timeout time

ROT set charge timeout time

ROT	charge timeout time
1k	disable, no timeout
68k	4h
120k	12h
NC	24h

9.13 Charge NTC

IP2326 support NTC protection function, and work with NTC resistor to detect the temperature of the battery.

If the NTC function is not required, pull down to GND with a 51kOhm resistor.

IP2326 releases a 20 uA current through the NTC pin and then detects the voltage across the NTC resistor to determine the temperature. Turning the charge when the temperature exceeds the set temperature.

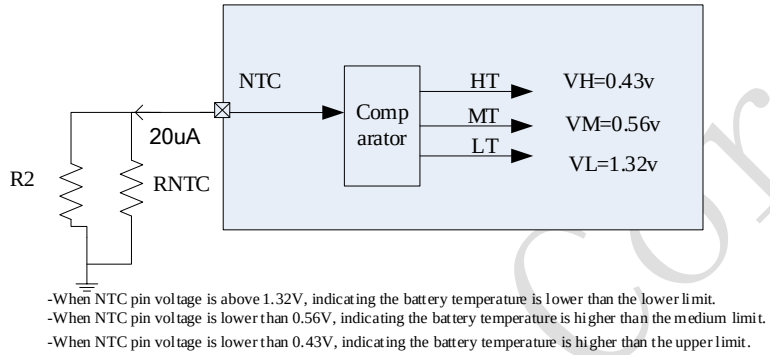


Figure 9 NTC circuit

When IP2326 detects the NTC pin voltage between 0.56V~1.32V, the battery is normal, the charging will be in normal working status.

When IP2326 detects the NTC pin voltage between 0.43V~0.56V, it indicates that the battery temperature is on the high side, the charging current is reduced by half.

When IP2326 detects the NTC pin voltage drop to less than 0.43V, it indicates that the battery temperature is too high, stop charging.

When IP2326 detects the NTC pin voltage rising to more than 1.32V, it indicates that the battery temperature is too low, stop charging.

Example: RNTC = 100K thermistor (B = 4100), R2 = 82K, corresponding temperature and NTC pin voltage:

Temperature (℃)	RNTC resistor value	R2//RNTC value	NTC pin voltage
0	346.7k	66.3k	1.32V
45	41.2k	27.8k	0.56V
55	28.4k	21.1k	0.43V

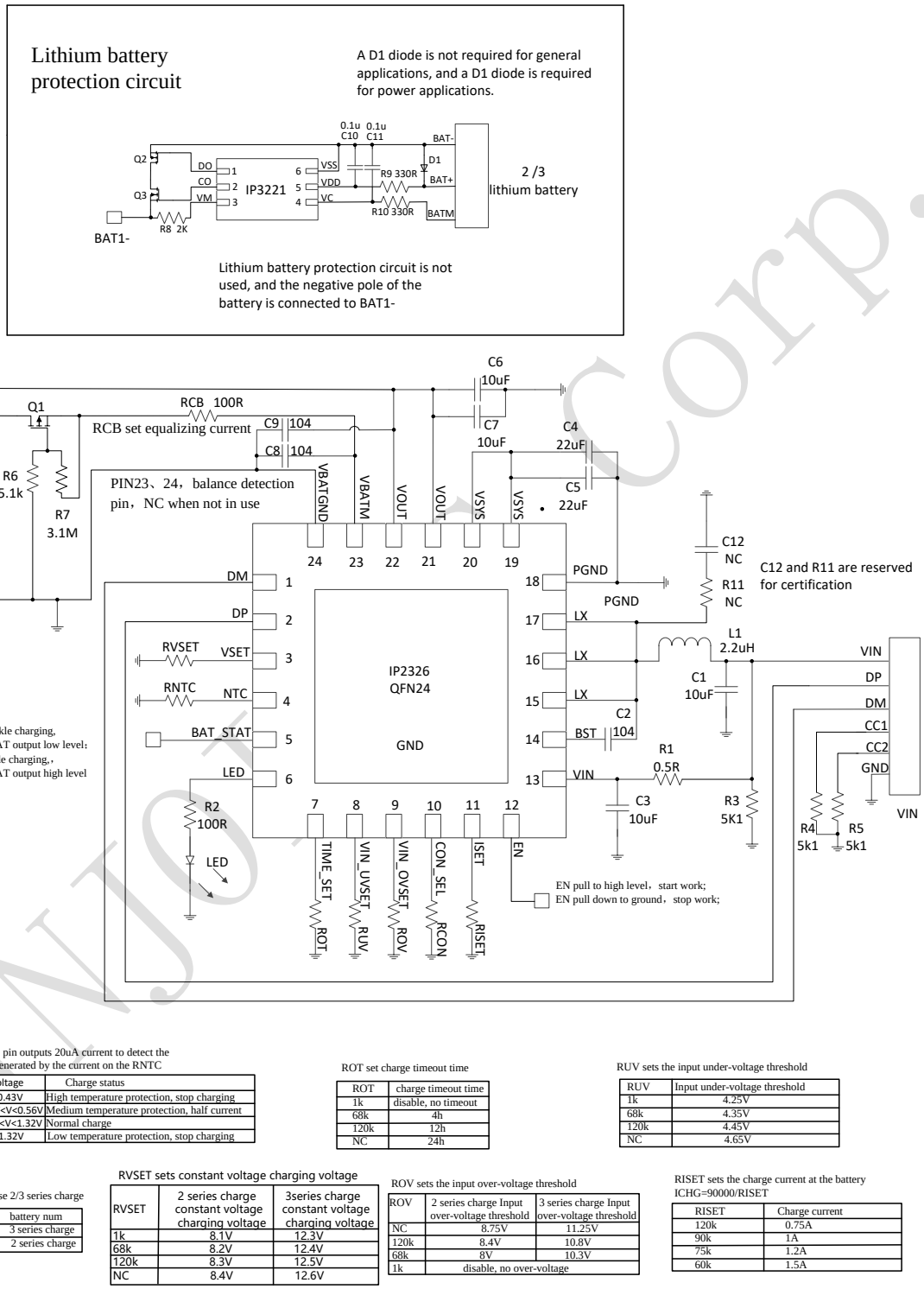
9.14 Charge Status Indication LED

Battery charging LED indicator light, charging process LED light, full charge LED out, detected abnormal LED flashing.

9.15 BAT_STAT Indication

BAT_STAT indicates charging status, low level output when trickle charging, high level output after constant current charging

10.Typical Application Schematic



The NTC pin outputs 20uA current to detect the voltage generated by the current on the RNTC

NTC voltage	Charge status
V<0.43V	High temperature protection, stop charging
0.43V<V<0.56V	Medium temperature protection, half current
0.56V<V<1.32V	Normal charge
V>1.32V	Low temperature protection, stop charging

ROT set charge timeout time

ROT	charge timeout time
1k	disable, no timeout
68k	4h
120k	12h
NC	24h

RUV sets the input under-voltage threshold

RUV	Input under-voltage threshold
1k	4.25V
68k	4.35V
120k	4.45V
NC	4.65V

RCON choose 2/3 series charge

RCON	battery num
1k	3 series charge
NC	2 series charge

RVSET sets constant voltage charging voltage

RVSET	2 series charge constant voltage charging voltage	3series charge constant voltage charging voltage
1k	8.1V	12.3V
68k	8.2V	12.4V
120k	8.3V	12.5V
NC	8.4V	12.6V

ROV sets the input over-voltage threshold

ROV	2 series charge Input over-voltage threshold	3 series charge Input over-voltage threshold
NC	8.75V	11.25V
120k	8.4V	10.8V
68k	8V	10.3V
1k	disable, no over-voltage	

RISET sets the charge current at the battery
ICHG=90000/RISET

RISET	Charge current
120k	0.75A
90k	1A
75k	1.2A
60k	1.5A

Figure 10 Typical Application Schemati

11.BOM

No	Part Name	Type &Specification	Units	Quantity	Location	Note
1	IC	IP2326	PCS	1	U1	Charging management chip
2	IC	IP3221	PCS	1	U2	Lithium battery protection chip
3	Inductance	CD43	PCS	1	L1	Saturate current (Isat), temperature rise current (Idc) larger than 5A, DCR less than 20mΩ, inductance 2.2uH @ 500kHz
4	PMOS	3401	PCS	1	Q1	
5	NMOS	RU207C	PCS	2	Q2、Q3	
6	Diode	RS1M	PCS	1	D1	A D1 diode is not required for general applications, and a D1 diode is required for power applications。
7	SMD Capacitor	0805 10uF 25V 10%	PCS	4	C1、C3、C6、C7	If the withstand voltage value is greater than 16V, a chip ceramic capacitor is required
8	SMD Capacitor	0805 22uF 25V 10 %	PCS	2	C4、C5	If the withstand voltage value is greater than 16V, a chip ceramic capacitor is required
9	SMD Capacitor	0603 104 25V 10%	PCS	3	C2、C10、C11	
10	SMD Capacitor	NC	PCS	1	C12	Over-certified reservations
11	SMD Resistor	0603 0.5R 5%	PCS	1	R1	
12	SMD Resistor	0603 100R 5%	PCS	1	R2	
13	SMD Resistor	0603 5.1K 5%	PCS	4	R3、R4、R5、R6	
14	SMD Resistor	0603 3.1M 5%	PCS	1	R7	
15	SMD Resistor	0603 2K 5%	PCS	1	R8	
16	SMD Resistor	0603 330R 5%	PCS	2	R9、R10	
17	SMD Resistor	0603 NC	PCS	1	R11	Over-certified reservations
18	LED	0603	PCS	1	LED	LED indicator, maximum drive capacity 5mA
19	SMD Resistor	0603	PCS	1	RVSET	Set the constant voltage charging voltage; Choose

						according to your needs
20	SMD Resistor	0603 1%	PCS	1	RISET	Set the charging current; 1% accuracy
21	SMD Resistor	0603	PCS	1	RUV	Set the input undervoltage; Choose according to your needs
22	SMD Resistor	0603	PCS	1	ROV	Set the input overvoltage; Choose according to your needs
23	SMD Resistor	0603	PCS	1	ROT	Set the charging timeout; Choose according to your needs
24	SMD Resistor	0603	PCS	1	RCON	Choose 2 strings/3 strings to charge; Choose according to your needs
25	NTC Resistor	NTC 电阻	PCS	1	RNTC	When not in use, connect the 51K resistor to the ground;
26	SMD Resistor	1206 100R 5%	PCS	1	RCB	The equalization current is set, and the equalization function can be dispensed with when the equalization function is not used
27	SMD Resistor	0603 104 10%	PCS	2	C8、C9	You can do without the equalization function when you are not using it

12.MARK DESCRIPTION

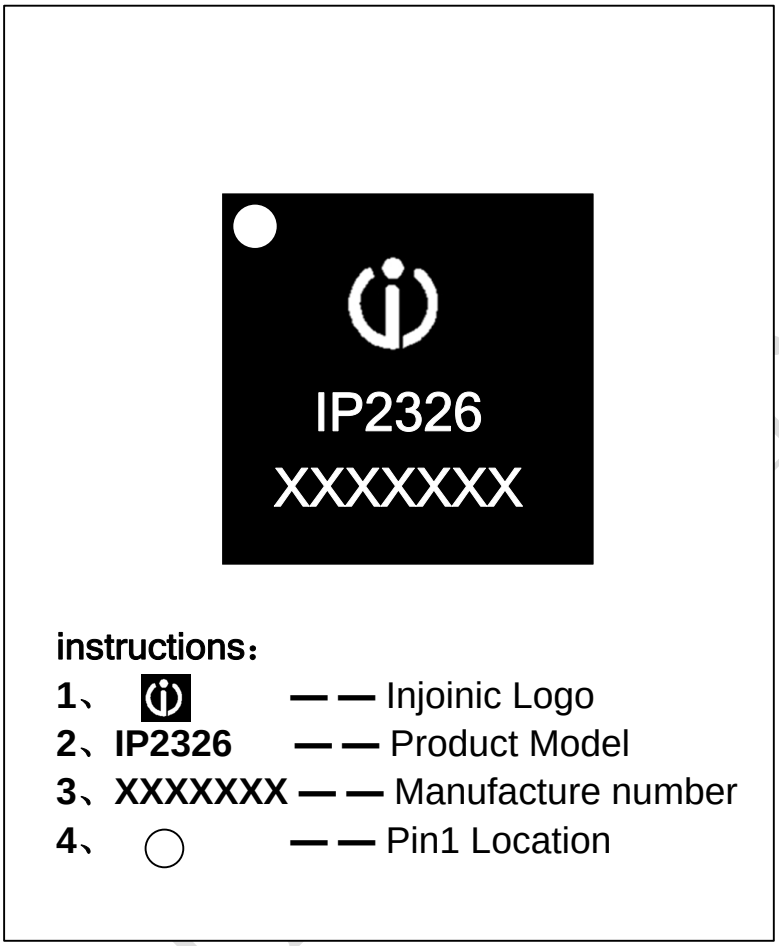
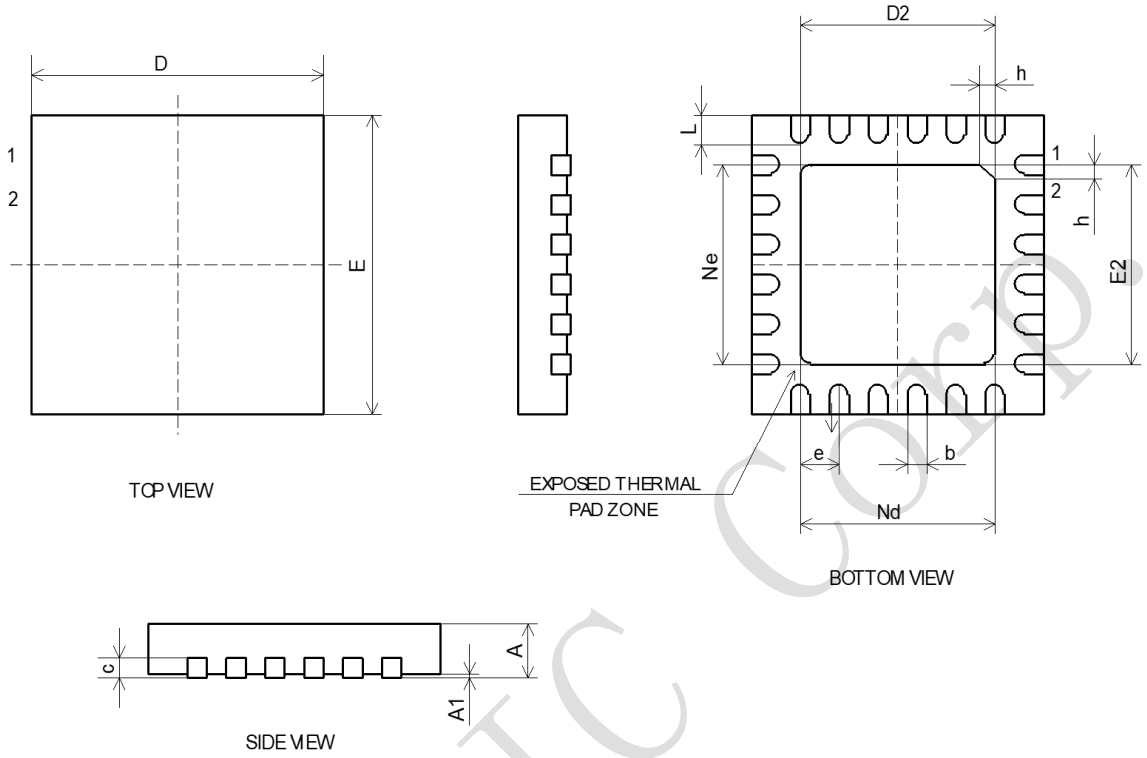


Figure 11 Screen printing illustration

13.PACKAGE INFORMATION



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	-	0.02	0.05
b	0.18	0.25	0.30
c	0.18	0.20	0.25
D	3.90	4.00	4.10
D2	2.40	2.50	2.60
e	0.50BSC		
Ne	2.50BSC		
Nd	2.50BSC		
E	3.90	4.00	4.10
E2	2.40	2.50	2.60
L	0.35	0.40	0.45
h	0.30	0.35	0.40

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