Equalization charging chip for two strings of batteries

1 Features

- Charge target voltage: 4.2V, support custom full voltage range: 4.05V~4.4V (step=50mV)
- Support customized lithium iron phosphate battery, charge target voltage range: 3.5V~3.8V (step=50mV)
- Charging current 500mA, support customized charging current range: 20mA~1A (step=20mA).
- Full stop charge detection current is 50mA
- Trickle charging current is 1/5 constant current charging current
- Built-in switching MOS, single on-state resistance of 150mΩ
- Supports the detection of voltage difference between two strings of batteries to realize balanced charging.
- Two status indication output pins
- Switching MOS withstanding voltage greater than 10V, supporting negative voltage resistance.
- Hardware-implemented switching timing for high reliability
- Low standby power consumption, battery consumption less than 3uA
- Support LED charging status indication function, support constant current function (LED current limiting resistor can be omitted)
- Support a variety of protection functions: IC overtemperature protection, input undervoltage protection, input overvoltage protection
- ESD 4KV

2 Typical Applications

- Charging two strings of lithium batteries

3 Description

IP2305 is a two series batteries equalization charging chip, built-in maximum 1A linear charging and series-parallel switching circuit, which can realize equalization charging for 2 series batteries.

The IP2305 features three complete charging processes, Trickle Charge (TC), Constant Current (CC) and Constant Voltage (CV) charging; Trickle Charge (TC) stage pre-charges a fully discharged battery for recovery; Constant Current (CC) mode safely delivers a fast buck charge; and the final stage, Constant Voltage (CV) charging, ensures that the battery's full capacity is safely reached。

IP2305 integrates series-parallel switching MOS, and the on-resistance of single switching MOS is 150 mΩ, which can switch 2 strings of batteries into a single battery charging; the control timing of the switching MOS is realized by hardware, and the switching reliability is high;

IP2305 supports the detection of voltage difference between two strings of batteries, if the voltage of 2 batteries is more than 30mV, it will charge the battery with low voltage first to ensure the equalization of 2 batteries charging;

IP2305 supports one LED charge status indication pin and two battery status indication pins. When switching to the corresponding battery, B1_SAT and B0_SAT will output high level correspondingly to indicate the currently connected battery;

IP2305 has an input under-voltage protection function, which can intelligently adjust the charging current and self-adapt to the load capacity of the adapter to prevent pulling the adapter off.

The IP2305 is available in ESOP8 package.

Directory

4 Simplify the application schematic

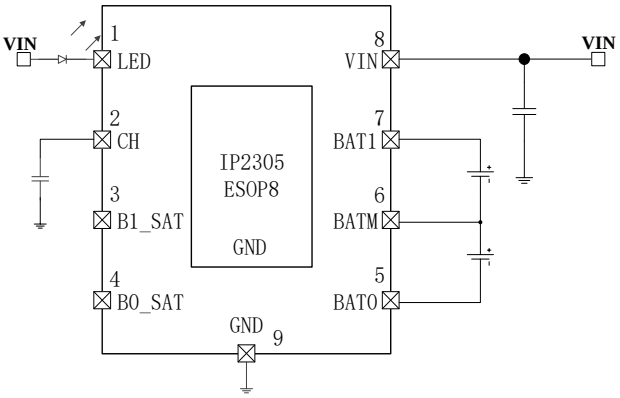

Figure 1 Simplify the application schematic

5 Modify records

NOTE：The page numbers of the previous version may differ from the page numbers of the current version.

Initial release version V1.00（2024.3）

updated version 1.01（2024.6）	**Page**
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6 Common Model

Type name	Function
IP2305	Standard Model, Charging current is 500mA
IP2305_1A	Charging current 1A
IP2305_DA_1A	Charging current 1A, Modify the light display to dual-light mode, red light during charging, green light when full.

7 PIN Description

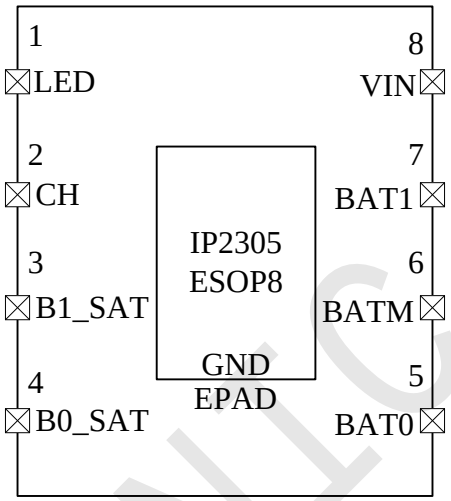

Figure 2 Pin of IP2305

Pin Name	Pin Num	Pin Description
LED	1	Charge indication pin, supports constant current function (LED current limiting resistor can be omitted)
CH	2	Charging Intermediate Node
B1_SAT	3	BAT1 toggle indication output pin, outputs high when the upper battery (BAT1 and BATM) is switched to CH and GND
B0_SAT	4	BAT0 toggle indication output pin, outputs high when the following battery (BATM and BAT0) is toggled to CH and GND
BAT0	5	Series battery negative pin, BAT0 negative connection pin
BATM	6	Series battery center pin, BAT0 positive, BAT1 negative connection pin
BAT1	7	Series battery positive pin, BAT1 positive connection pin
VIN	8	5V input pin
GND	EPAD	GND

8 Limit parameters

Parameters	Symbol	Value	Unit
BAT1 voltage range	BAT1 to BATM	-0.3~10	V
BAT0 voltage range	BATM to BAT0	-0.3~10	V
BAT1 to BAT0 Pin Voltage Range	BAT1 to BAT0	-0.3~20	V
BAT0 pin voltage range	V_{BAT0_GND}	-10~0.3	V
BATM Pin voltage Range	V_{BATM_GND}	-0.3~10	V
BAT1 pin voltage range	V_{BAT1_GND}	-0.3~15	V
Other pin input voltage range	V_{MAX}	-0.3~7.5	V
Operating temperature range	T_A	0 ~ 70	℃
Junction Temperature Range	T_J	-40 ~ 150	℃
Storage Temperature Range	T_{stg}	-65 ~ 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.

9 Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input Voltage	V_{IN}	4.5	--	6	V
Charge Current	I_{CC}		--	1	A

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

10 Electrical Characteristics

Unless otherwise specified,TA=25℃,VIN=5V，

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Charging System						
Input Voltage	V_{IN}		4.5	5	5.5	V
Input under-voltage threshold	V_{IN-UV}			4.5		V
Input over-voltage threshold	V_{IN-OV}			6		V
Input overvoltage protection hysteresis				200		mV

Input Current	I_{VIN}	VIN=5V，VBAT=NC，NO LED		1	2	mA
Standby Current	I_{CC}	IP2305	0.45	0.5	0.55	A
		IP2305_1A	0.9	1	1.1	A
Charge Target Voltage	V_{CV}		4.16	4.2	4.24	V
Full charge stop detection voltage	V_{SV}			V_{CV}-0.05		V
Charging voltage after full charge	V_{RC}			V_{CV}-0.1		V
Trickle over constant current voltage	V_{TK}	VIN=5V	2.9	3.0	3.1	V
Trickle Charge Current	I_{TK}	VIN=5V，VBAT<2.9V		1/5 I_{CC}		mA
Charge Cut-off Current	I_{STOP}			50	70	mA
Battery Switching Systems						
Standby Current	$I_{standby-BAT0}$	VIN=NC， VBAT1-VBATM=3.7V，VBATM-VBAT0=3.7V		2	3	uA
	$I_{standby-BAT1}$			2	3	uA
BAT1 MOS on-resistance	R_{DSON_BAT1}	The upper battery (BAT1 and BATM) switches to CH and GND		150		mΩ
BAT0 MOS on-resistance	R_{DSON_BAT0}	The following battery (BATM and BAT0) is switched to CH and GND		150		mΩ
2-cell differential pressure detection threshold	V_{TH}	VBAT1-VBATM and VBATM-VBAT0 differential pressures		30		mV
Battery voltage detection time	T_{DET}			1		ms
Battery voltage detection interval	T_{CHG}			1		s
Indicates pin output current	I_{STA_OUT}	Indicates when the pin output voltage is 0.9VIN		15		mA
Indicates pin input current	I_{STA_IN}	Indicates when the pin input voltage is 0.1VIN		15		mA
LED drive current	I_{LED}	Constant current input current when LED is on		3		mA
Thermal shutdown temperature	T_{OTP}	rising temperature	130	140	150	℃
Thermal shutdown temperature hysteresis	ΔT_{OTP}		30	40	50	℃

11 Function Description

11.1 Functional Block Diagram

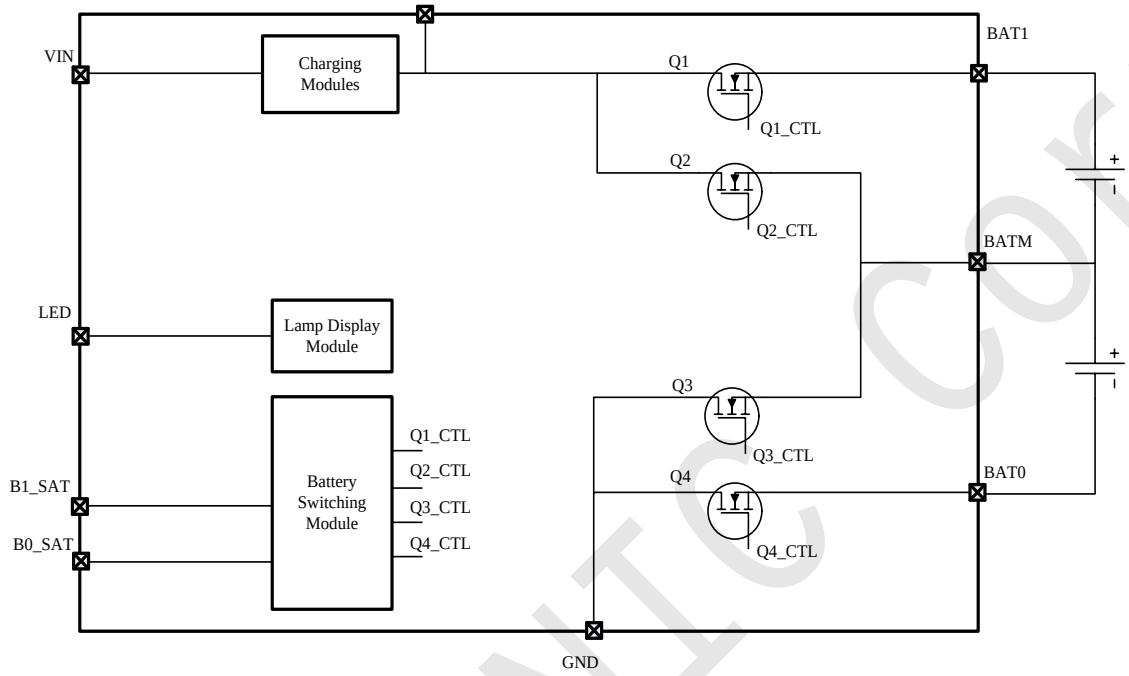

Figure 3 IP2305 Functional Block Diagram

11.2 Charge Process

The IP2305 uses a full trickle/constant/constant voltage charging mode.

When the battery voltage is less than the trickle to constant current voltage V_{TK}, it is charged with trickle charging current I_{TK}.

When the battery voltage is greater than V_{TK}, charge with constant current charging current I_{CC}.

When the battery voltage approaches the set constant voltage charging voltage V_{CV}, the charging voltage V_{CV} remains unchanged, the charging current slowly decreases, and the constant voltage charging mode is entered.

After entering the constant voltage charging mode, if the charging current is less than the full charge stop detection current I_{STOP}. The charging will be stopped first, and then detect whether the battery voltage is higher than the stop voltage V_{SV}. If it is higher than the charging stop voltage V_{SV}, stop charging. If the stop voltage is lower, charging continues.

After the battery is fully charged and stopped, and the input VIN continues to be active, if the battery voltage is less than V_{RC}, it will enter the full charge stage and start the charging process again.

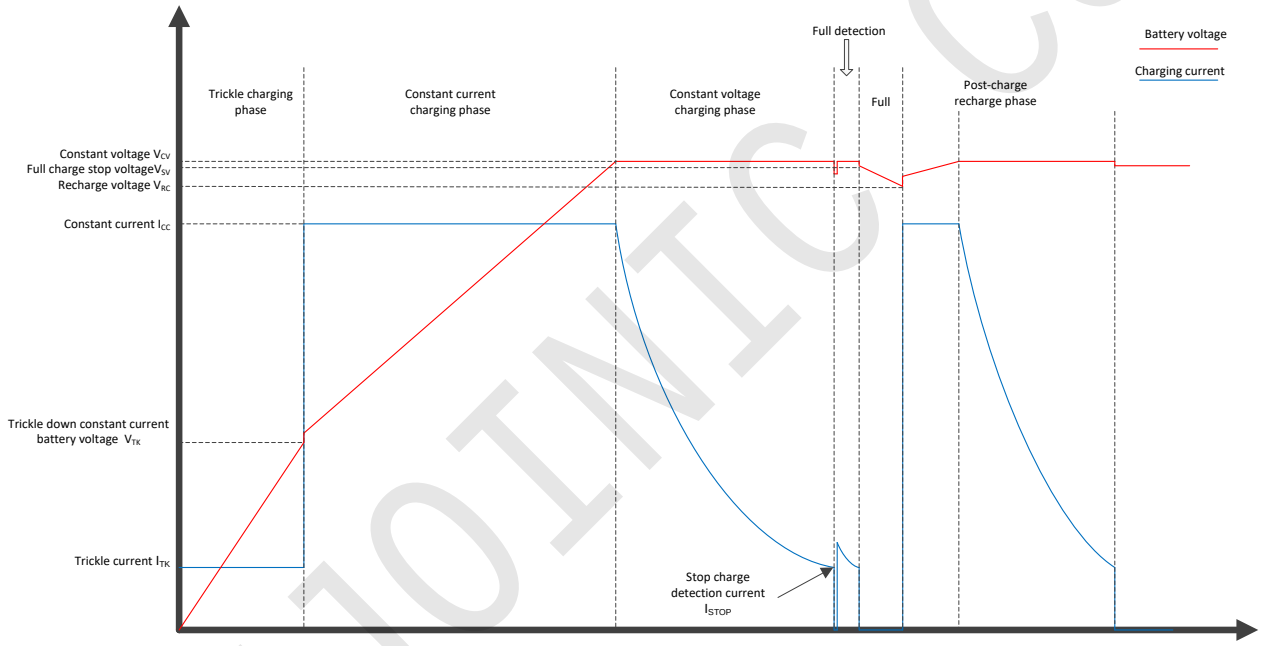

Figure 4 IP2305 Schematic diagram of the charging process

11.3 Charge protection

IP2305 has a perfect protection function with integrated input under-voltage, input over-voltage, IC over-temperature protection and other functions to ensure stable and reliable operation of the system.

IP2305 has VIN input under-voltage protection function, when detecting the input voltage close to 4.5V, it will automatically adjust to reduce the charging current to ensure that it will not pull the adapter.

IP2305 integrates over-temperature protection function, which will force charging to stop when the internal temperature of the chip is detected to be over 140 degrees..

11.4 Charging LED indication

The standard product light display is: LED blinking during charging (1S light, 1S extinguish), after charging full LED is always on. Abnormal state (over-temperature protection) LED flashes (0.5S bright, 0.5S extinguished).

LED output is current limiting mode, 3mA current limiting when the light is on, support LED light without current limiting resistor; high resistance state when the light is off.

IP2305_DA_1A can be single pin point double lights, the lights show: charging process LED_R on, LED_G off. When fully charged, LED_R is off and LED_G is on. LED_R and LED_G flash alternately (0.5S on, 0.5S off) in abnormal state (over-temperature protection)..

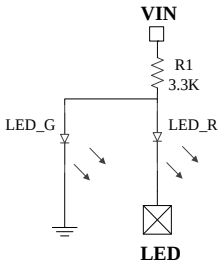

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Figure 5 IP2305_DA_1A Schematic diagram of single pin point double lamp

11.5 Battery switching strategy

IP2305 can realize the function of detecting the voltage difference between two strings of batteries and realize the equalization charging of two batteries.

When the voltage difference between the two batteries is greater than the voltage difference threshold VTH, IP2305 will think that the voltage of the two batteries is not balanced, and it will prioritize charging the battery with low battery voltage. After charging for 1s, stop charging for 1ms to detect the battery voltage until the voltage difference between the two batteries is less than the voltage difference threshold VTH.

When VBAT1-VBAT0>VTH, it is STA1 state, IP2305 prioritizes charging BAT0, internal MOS Q1 and Q3 turn off, Q2 and Q4 turn on, B0_SAT pin will be set to high, and the rest of the cases are low.

When VBAT0-VBAT1>VTH, it is STA3 state, IP2305 prioritizes charging BAT1, internal MOS Q2 and Q4 turn off, Q1 and Q3 turn on, B1_SAT pin will be set high, and the rest of the cases are low.

When the voltage difference between the two batteries is less than the voltage difference threshold VTH, it is STA2 state, IP2305 will think that the two battery voltages are equalized, and it will take turns to switch to equalize the charging of the two batteries, first charging one battery for 1s, then stopping for 1ms to detect the battery voltage, and then charging the other battery, and keep on cycling.

When the IP2305 detects the voltage difference between two batteries, both B0_SAT and B1_SAT are set high.

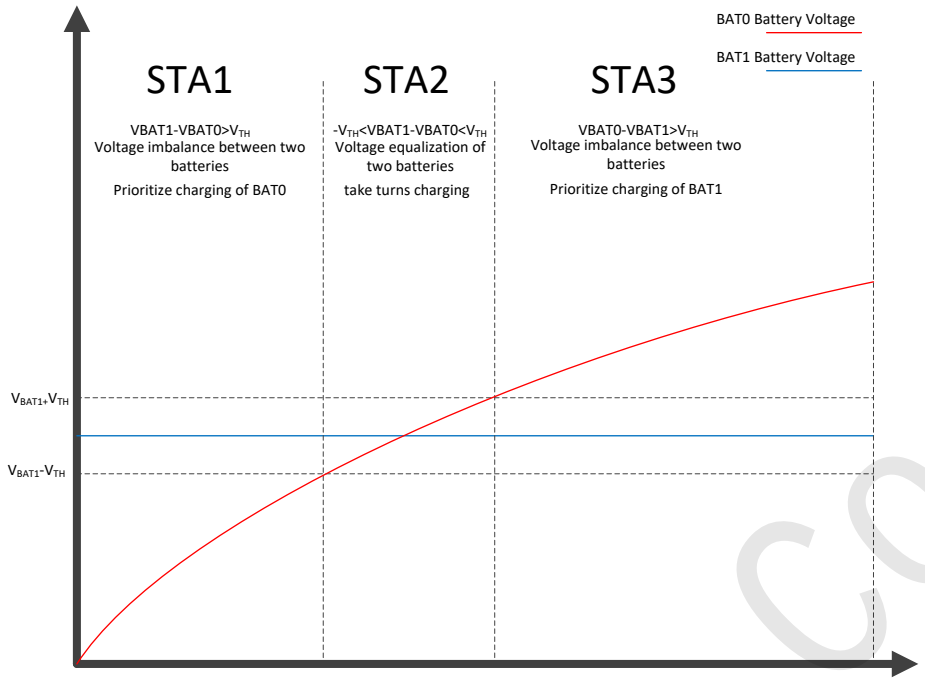


Figure 6 Schematic diagram of IP2305 battery switching strategy

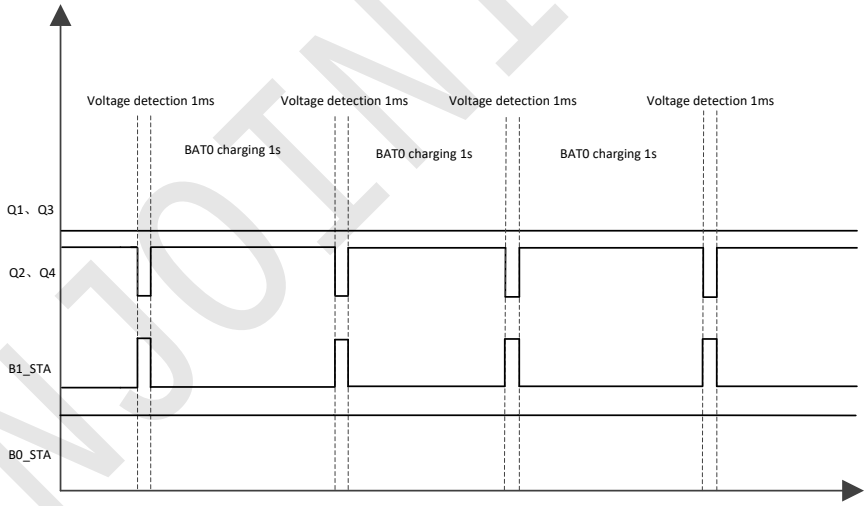


Figure 7 Charge detection schematic for STA1 state (VBAT1-VBAT0>VTH)

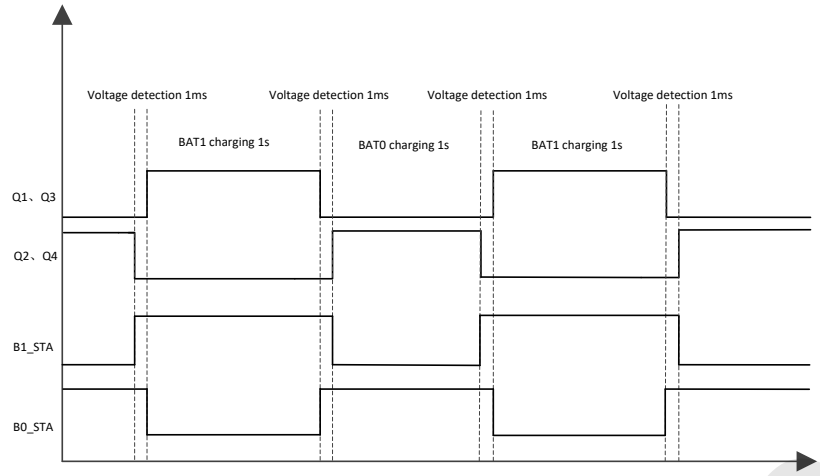


Figure 8 STA2 state (-VTH<VBAT1-VBAT0<VTH) charging detection schemat

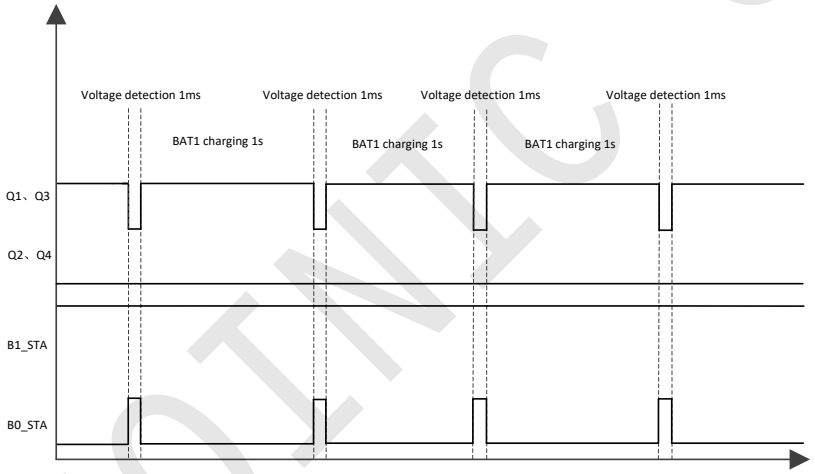


Figure 9 STA3 (VBAT0-VBAT1>VTH) state charging detection schematic

11.6 Actual Battery Charging Curve

Use the IP2305 to charge two series-connected batteries. Two series-connected real batteries with different initial voltages were charged at VIN=5V with a 500mA charging current. The initial voltages of the two batteries were 3.2V and 3.7V, respectively, and both batteries had a voltage of 4.2V when fully charged.

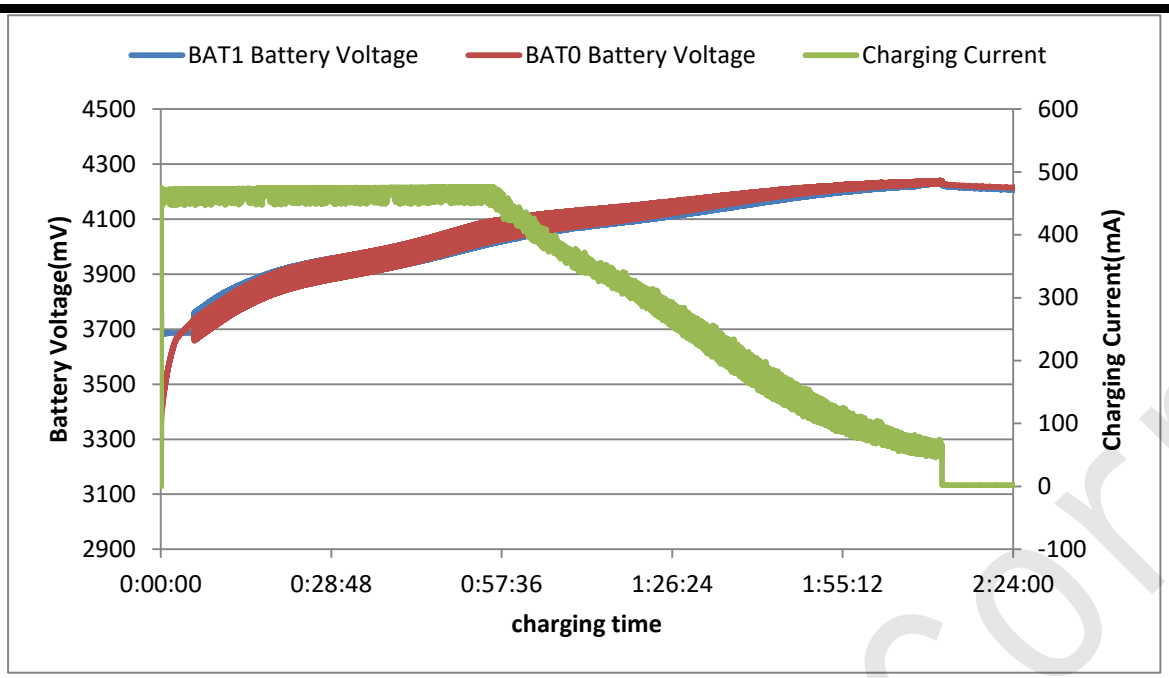


Figure 10 IP2305 actual battery charge curve

Charge two series-connected real batteries with different initial voltages at VIN=5V with a 1A charging current. The initial voltages of the two batteries were 3.2V and 3.7V, respectively, and both batteries had a voltage of 4.2V when fully charged.

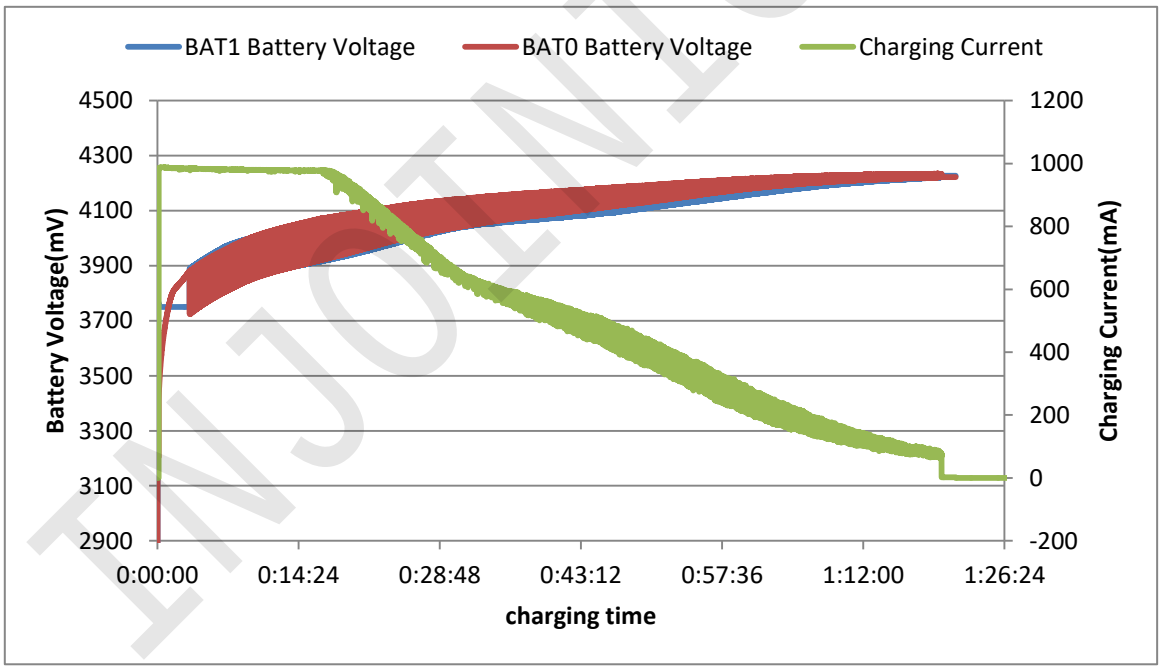


Figure 11 IP2305_1A actual battery charge curve

12 Typical Application Schematic

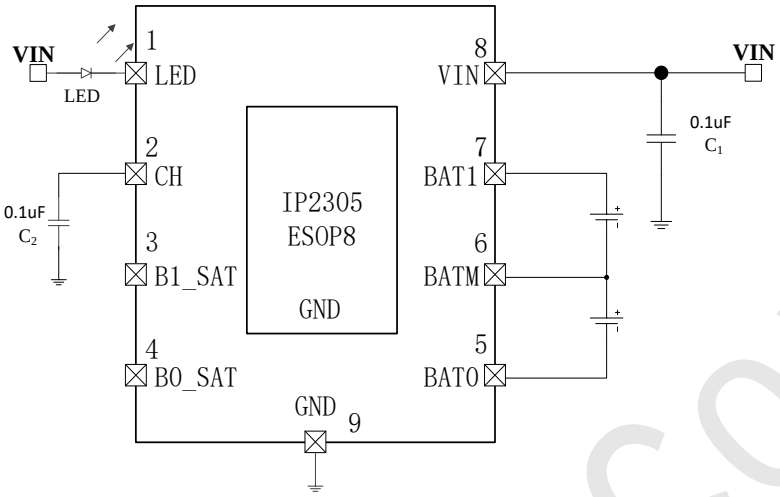


Figure 12 Typical Application Schematic

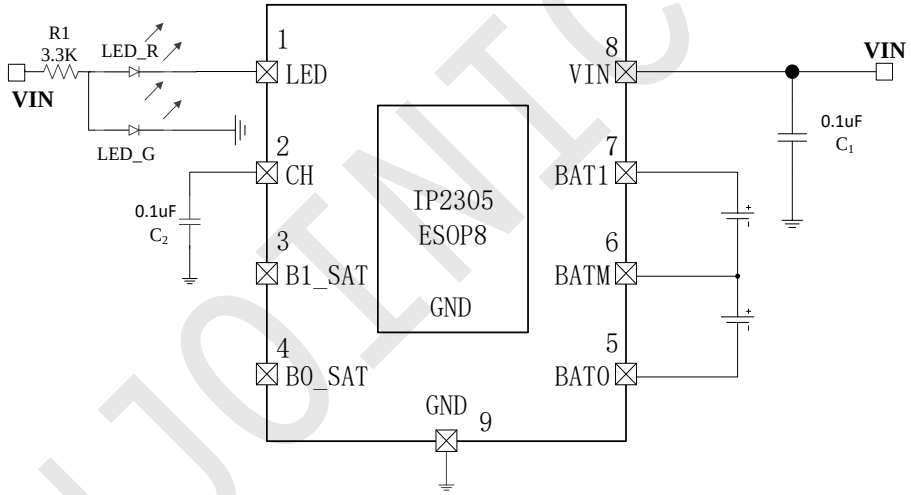


Figure 13 IP2305_DA_1A Typical Application Schematic for Single Pin Dual Lamps

13 BOM

No.	Part Name	Type &Specification	Units	Quantity	Location	Note
1	IC	IP2305	PCS	1	U1	
2	SMD capacitors	0603 0.1uF 25V 10%	PCS	2	C_1、C_2	
3	LED	0603	PCS	1	LED	
4	SMD resistors	0603 3.3K 5%	PCS	1	R1	Single Pin Dual Lamp Circuit
5	LED	0603	PCS	1	LED_R、LED_G	

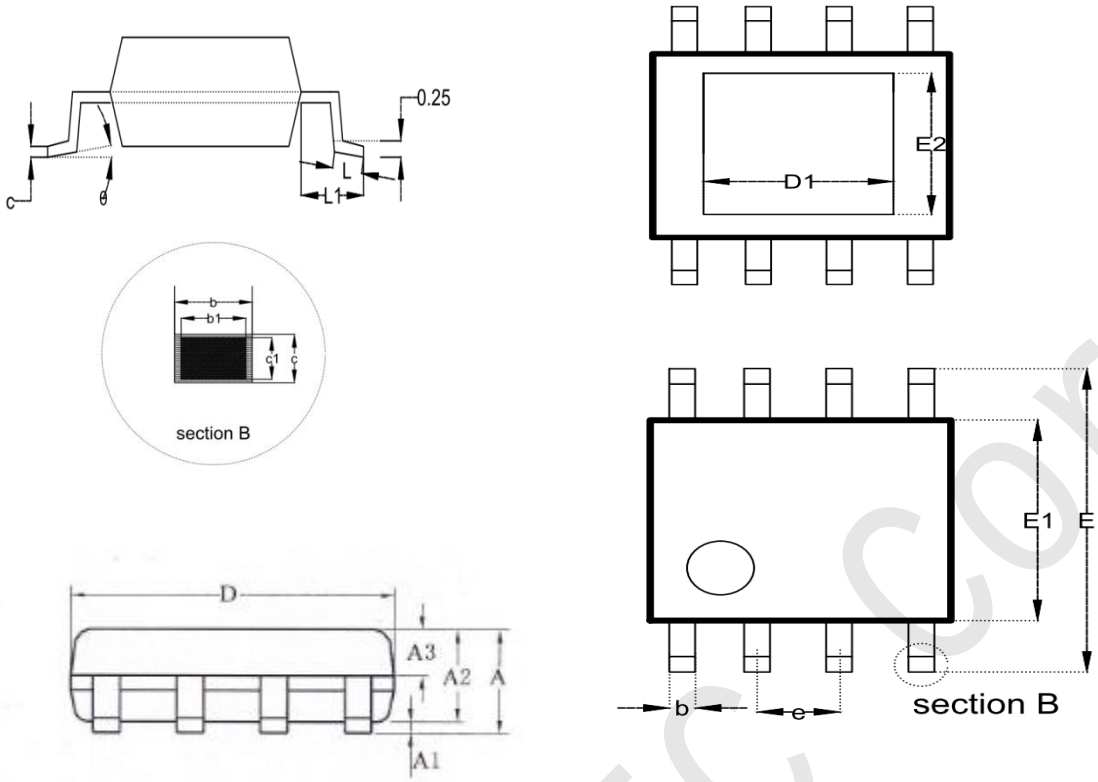
14 Silkscreen

Instruction:

1、 --Injoinic Logo
2、IP2305 --Product name
3、XXXXXXX --Product number
4、 ○ --PIN1 Position

Figure 14 IP2305 Silkscreen

15 Package



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	--	--	1.65
A1	0.05	--	0.15
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.39	--	0.48
b1	0.38	0.41	0.43
c	0.21	--	0.25
c1	0.19	0.20	0.21
D	4.70	4.90	5.10
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	1.27BSC		
L	0.50	0.60	0.80
L1	1.05BSC		
θ	0	--	8 °
D1	--	3.10	--
E2	--	2.21	--

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