

Fully-integrated power bank System-On-Chip with 2.1A charger, 2.4A boost converter and DCP support

1 Features

- **Synchronous switching charger and synchronous boost converter**
 - ✧ 2.1A synchronous switching charger, 2.4A synchronous boost converter
 - ✧ boost converter efficiency up to 96%
 - ✧ Switching charger efficiency up to 97%
 - ✧ Integrated power-path management, charging batteries and charging cellphones at the same time
- **Charger**
 - ✧ Adaptive charging current control, excellent adapter compatibility
 - ✧ Charger voltage accuracy $\pm 0.5\%$
 - ✧ Support 4.20V, 4.30V and 4.35V batteries
 - ✧ Support battery thermal protection (with NTC resistor)
- **State of charge (SOC) indicator**
 - ✧ Integrated 14bit ADC and fuel gauge
 - ✧ Integrated LED controller supports 5/4/3 LEDs as the SOC indicator
 - ✧ Configurable charging/discharging curve makes the SOC indicate LEDs more even
- **Fully featured**
 - ✧ Integrated flashlight controller
 - ✧ Integrated cellphone plug-in and plug-out detector
 - ✧ Integrated DCP (Dedicated Charging Port) controller monitors USB data line voltage and automatically provides the correct electrical signatures on the data lines to charge compliant devices
- **Low power**
 - ✧ Smart load detector, switching to standby mode automatically
 - ✧ $<100 \mu\text{A}$ standby current
- **Ultra simplified BOM**
 - ✧ Integrated power FET, charging/boosting with a single inductor
- **Multiple protections, high reliability**
 - ✧ Output over-current, over-voltage, short-circuit protection
 - ✧ Input over-voltage, over-current, battery over-charge, over-drain, over-current protection

- ✧ Thermal regulation and thermal shutdown, battery NTC protection
- ✧ ESD 4KV, maximum 11V transit over-voltage sustainable
- **Fully customizable**
 - ✧ I2C interface makes customization flexible and low-cost

2 Applications

- Power bank, Portable Charger
- Mobile Phones, Smart Phones, Handheld Devices, Portable Media Player, Tablet

3 Description

IP5209 is a fully-integrated multi-function power management SOC. It integrates a boost converter, a Li battery charger management system and a battery state of charge indicate controller. It provides a turn-key solution for power bank and portable charger applications.

IP5209's high integration and rich features make the minimized component number in application. It can effectively downsize the application and lower the BOM cost.

IP5209 only needs a single inductor to realize step-down and step-up.

IP5209's synchronous step-up converter provides max 2.4A output current. Its efficiency is up to 96%. It can switch to standby mode at empty load automatically

IP5209's synchronous switching charger provides max 2.1A charging current. Its efficiency is up to 97%. It regulates the charging current by IC temperature and input voltage.

The built-in 14bit ADC in IP5209 measures battery voltage and current accurately. ADC data are available on I2C interface. IP5209 has integrated a fuel gauge algorithm, acquiring

battery's state of charge precisely.

IP5209 is available in QFN24.

IP5209 can customize battery's SOC curve, and indicate the SOC accurately, with the SOC indicator of 3/4/5 LEDs and flashlight function.

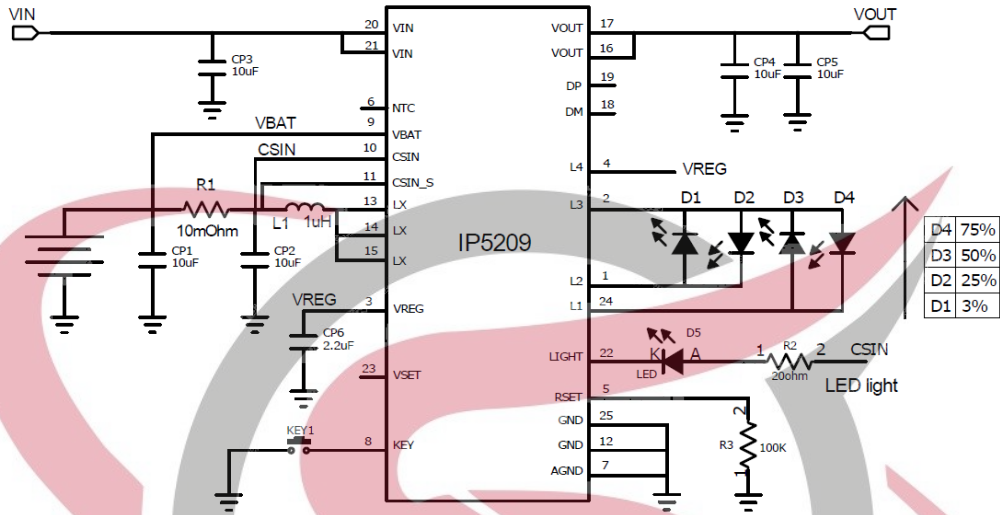


Fig 1 Simplified application schematic (4 LEDs as the SOC indicator)



4 Pin definition

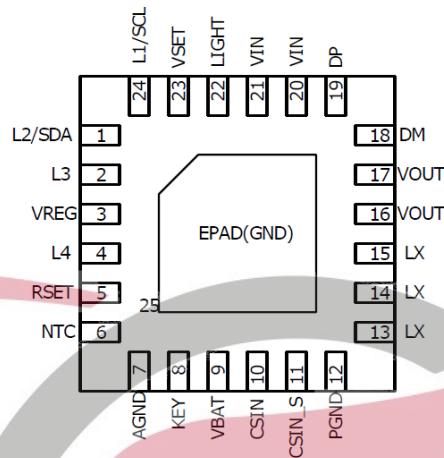


Fig 2 IP5209 Pin Diagram

Pin		Descriptions
Index	Name	
1	L2/SDA	Battery indicator pin2/I2C SDA
2	L3	Battery indicator pin3
3	VREG	Regulator output pin
4	L4	Battery indicator pin4
5	RSET	Battery resistance select
6	NTC	NTC pin
7	AGND	Analog gnd
8	KEY	Key input pin
9	VBAT	Battery voltage sense pin
10	CSIN	Current sense input
11	CSIN_S	Current sense input
12	PGND	Power ground
13、14、15	LX	DCDC switch node, connect inductor
16、17	VOUT	DCDC 5v OUTPUT pin
18	DM	USB DM
19	DP	USB DP
20、21	VIN	Charger 5V input pin
22	LIGHT	LED lighting driver
23	VSET	Battery voltage select
24	L1/SCL	Battery indicator pin1/I2C SCL
25	GND	EPAD, should be connected to GND

5 IP serials power bank IC selection table

IC Model	Charging /Discharging		Main features						Package	
	boost	Charger	LED Num	Light	Push Button	I2C	DCP	QC2.0 quick charge	Package	Package compatibility
IP5101	1.0A	1.0A	1,2	-	-	-	-	-	eSOP8	
IP5305	1.2A	1.2A	1,2,3,4	✓	✓	-	-	-	eSOP8	
IP5206	2A(Max)	1.5A	3,4,5	✓	✓	-	-	-	eSOP16	PIN2PIN
IP5108	2.0A	2.5A	3,4,5	✓	✓	✓	-	-	eSOP16	
IP5207	1.2A	1.2A	3,4,5	✓	✓	-	-	-	QFN24	PIN2PIN
IP5109	2.1A	2.1A	3,4,5	✓	✓	✓	-	-	QFN24	
IP5209	2.4A	2.1A	3,4,5	✓	✓	✓	✓	-	QFN24	


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6 Absolute maximum ratings

Parameter	symbol	value	Unit
Port input voltage range	V_{IN}	-0.3 ~ 5.5	V
Operating free-air temperature range	T_A	0 ~ 70	°C
Junction temperature	T_J	-40 ~ 150	°C
Storage temperature	T_{stg}	-60 ~ 150	°C
Thermal resistance (from junction to ambient air)	θ_{JA}	40	°C/W
Human-body model (HBM)	ESD	4	KV

* 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 under recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

7 Recommended operation conditions

Parameter	symbol	MIN	Typical	MAX	Unit
Input voltage	V_{IN}	4.5	5	5.5	V
Load current	I	0	2.1	3.0	A
Operating ambient temperature	T_A	0	--	70	°C

*Beyond these operation conditions, the device's performance will not be guaranteed



8 Electrical Characteristics

TA=25°C, L=1uH unless otherwise noted

Parameter	symbol	Test condition	MIN	TYP	MAX	Unit
Charger system						
Input voltage	V _{IN}		4.5	5	5.5	V
Input current (charging)	I _{VIN}	VIN=5V, fs=1.6 MHz	1	3	5	mA
Input current (standby)		VIN=5V, Device not switching	45	75	100	uA
Target charge voltage	V _{TRGT}		4.16	4.2	4.24	V
Charge current	I _{CHRG}			2.1		A
Trickle charge current	I _{TRKL}	VIN=5v, BAT=2.7v	50	100	150	mA
Trickle charge stop voltage	V _{TRKL}		2.9	3	3.1	V
Recharge threshold	V _{RCH}		4.08	4.1	4.13	V
Charger safety timer	T _{END}		20	24	27	Hour
Input under-voltage protection	V _{UVLO}	Rising voltage	4.4	4.5	4.6	V
Input under-voltage protection hysteresis	V _{UVLO}			200		mV
Boost system						
Battery operation voltage	V _{BAT}		3.0		4.4	V
Low Battery voltage	V _{BAT}	When Battery OCV voltage lower than V _{BAT} , the Boost will be shutdown	2.9	3.0	3.1	V
Low Battery voltage	V _{BAT}	When Battery voltage lower than V _{BAT} , the Boost will be shutdown	2.78	2.85	2.92	V
Battery operation current	I _{BAT}	V _{BAT} =3.7V, V _{OUT} =5.1V, fs=650KHz	2	3	5	mA
		VIN=5V, Device not switching	45	75	100	uA
DC-DC output voltage	V _{OUT}	V _{BAT} =3.7V @0A	5.0	5.12	5.23	V
		V _{BAT} =3.7V @2.0A	4.75	5	5.15	V
Output voltage ripple	ΔV _{OUT}	V _{BAT} =3.7V, V _{OUT} =5.0V, fs=650KHz	50	100	150	mV
Boost output current	I _{vout}			2.1	3.0	A
Boost output shutdown current	I _{off}		2.65	3.05	3.4	A

Load over-current detect timer	T_{UVD}	Output voltage continuously lower than 4.4V		30		ms
Load short-circuit detect timer	T_{OCD}	Output current continuously larger than 3.5A	150		200	us
Control system						
Switching frequency		Boost switching frequency	590	650	710	KHz
		Charger switching frequency	1.44	1.6	1.76	MHz
PMOS on resistance	r_{DSON}		35	40	45	mΩ
NMOS on resistance			25	30	35	mΩ
VREG output voltage	V_{REG}	VBAT=3.5V	3	3.1	3.2	V
Battery standby current	I_{STB}	VIN=0V, VBAT=3.7V	45	75	100	uA
LDO output voltage	I_{LDO}		30	50	80	mA
LED lighting current	I_{light}		20	30	40	mA
LED indicator current	I_{L1}		2	4	5	mA
	I_{L2}					
	I_{L3}					
Load removal detect timer	T_{loadD}	Load current continuously lower than 45mA	25	32	44	s
Push-button wake-up timer	$T_{OnDebounce}$		25	32	44	ms
Push-button light-on timer	$T_{Keylight}$		1.2	2	3	s
Thermal shutdown	T_{OTP}	Rising temperature	110	125	140	°C
Thermal shutdown hysteresis	ΔT_{OTP}			40		°C

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9 Function description

Boost converter

IP5209 integrates a 5V output step-up DCDC converter with 2.4A output capacity. It works at 650KHZ. When input voltage is 3.7V, its efficiency is 95% with the output of 5V/1A and 92.5% with the output of 5V/2A. Internal soft-start circuit prevents malfunction caused by starting inrush current. It integrate short-circuit, over-voltage, over-voltage protection, making the system stable and reliable.

IP5209's boost converter has a thermal regulation loop, which can adaptively regulate the output current to insure IC temperature below the set one.

Push Button

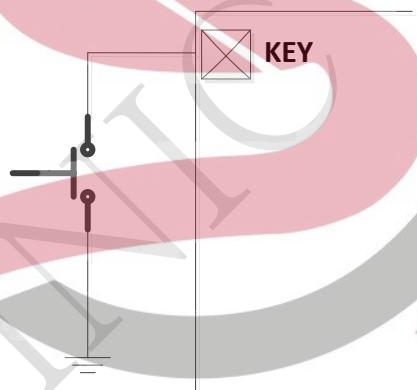


Fig 3 KEY button

Push button's connecting is shown in Fig 3. IP5209 can identify long push and short push.

- If button is pushed longer than 30ms but shorter than 2s, IP5209 will identify the action as short push. Short push will open SOC indicator LEDs and step-up converter
- If button is pushed longer than 2s, IP5209 will identify the action as long push. Long push will close step-up converter, SOC indicator LED and flashlight LED.
- If button is pushed shorter than 30ms, IP5209 will ignore the action.
- If two short push is detected within 1s, IP5209 will open or close flashlight LED

Fuel gauge and State Of Charge (SOC) indication

IP5209 has an integrated fuel gauge, which can indicate the battery's state of charge accurately.

IP5209 can support 3/4/5 LEDs as the SOC indicator with very simple configuration. By the

built-in identification algorithm, IP5209 can automatically identify how many LEDs are used as the SOC indicator.

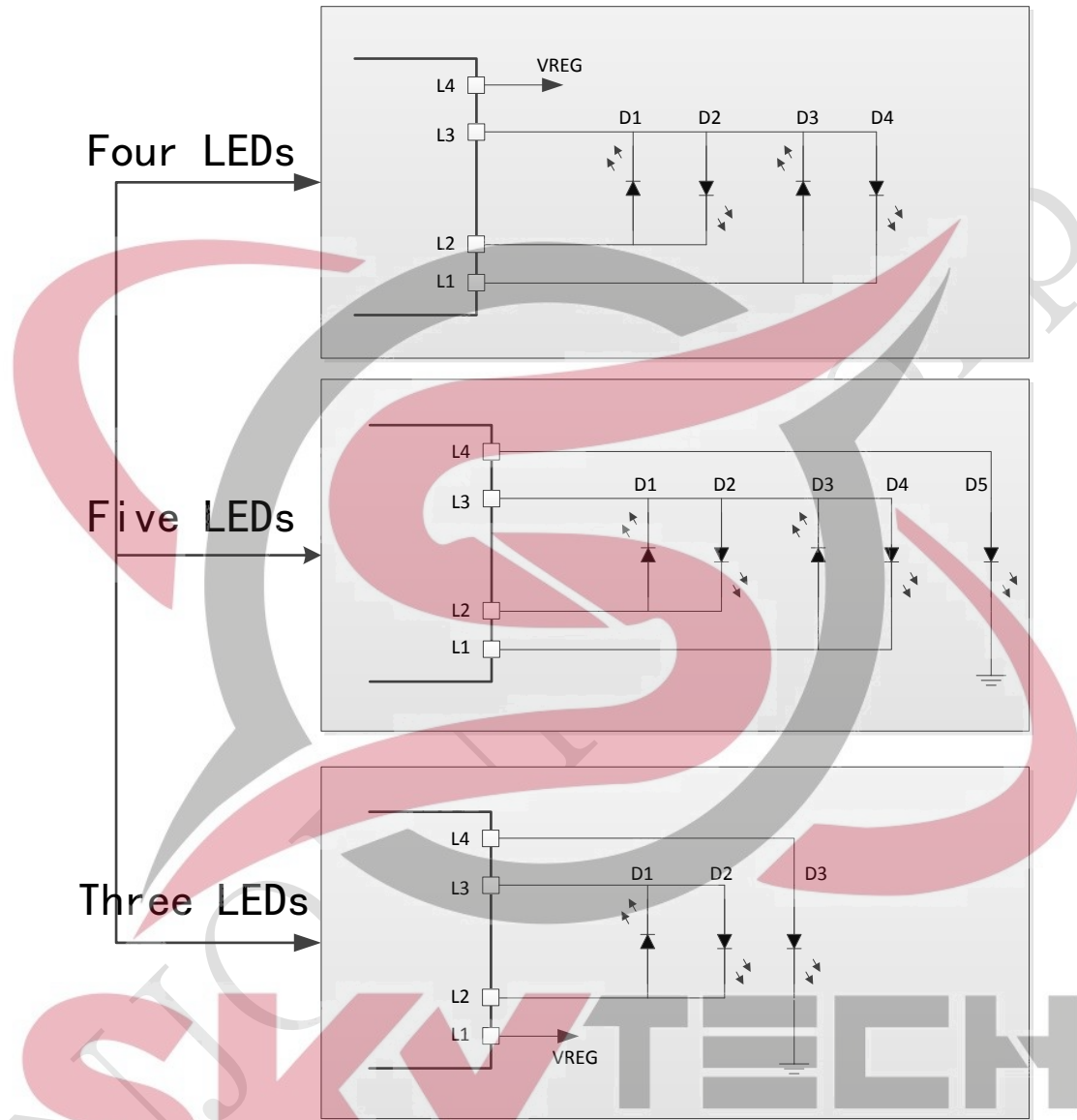


Fig 4 3/4/5 LED PIN configuration

Discharging mode, 4 LEDs as the indicator

SOC (%)	L1	L2	L3	L4
$SOC \geq 75\%$	ON	ON	ON	ON
$50\% \leq SOC < 75\%$	ON	ON	ON	OFF
$25\% \leq SOC < 50\%$	ON	ON	OFF	OFF
$3\% \leq SOC < 25\%$	ON	OFF	OFF	OFF
$0\% < SOC < 3\%$	1.5Hz blink	OFF	OFF	OFF

SOC=0%	OFF	OFF	OFF	OFF
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Charging mode 4 LEDs as the indicator

SOC (%)	L1	L2	L3	L4
Full	ON	ON	ON	ON
$75\% \leq \text{SOC}$	ON	ON	ON	1.5Hz blink
$50\% \leq \text{SOC} < 75\%$	ON	ON	1.5Hz blink	OFF
$25\% \leq \text{SOC} < 50\%$	ON	1.5Hz blink	OFF	OFF
$\text{SOC} < 25\%$	1.5Hz blink	OFF	OFF	OFF

The displays of 3 LEDs and 5 LEDs are similar to that of 4 LEDs. The corresponding SOC of each LED is presented in the following table.

	D1	D2	D3	D4	D5
3 LEDs	3%	66%	100%	NA	NA
4 LEDs	25%	50%	75%	100%	NA
5 LEDs	20%	40%	60%	80%	100%

Battery impedance setting

IP5209 can set the battery impedance by RSET pin which make the SOC indicator LEDs display more evenly. The relationships between the resistance connected to RSET and battery impedance are shown in the following table.

RSET resistance Kohm	Battery impedance (mOhm)
184	165
174	155
164	145
154	135
144	125
134	110
124	100
114	90
104	80
94	70
84	60
74	40
64	30
54	20

44	10
33	0

Automatic cellphone plug-in detect

IP5209 can automatically detect the cellphone's plug-in. When detecting the plug-in, IP5209 will wake up from standby mode and open the 5V step-up converter without push button action. IP5209 supports modules without push buttons.

Cellphone charging current smart detect

IP5209 integrates a DCP module which can smartly detect the cellphone's charging current. It automatically provides the correct signals on D+ and D-. It makes the cellphone's charging current to the maximum, accelerating the charging speed on cellphone.

IP5209 supports Apple, Samsung and BC1.2 interface's D+ D- specification

Supports D+ D- shorted USB DCP

Supports D+ 2.0V D-2.7V Apple 1.0A DCP

Supports D+ 2.7V D-2.0V Apple 2.0A DCP

Supports D+ 2.7V D-2.7V Apple 2.4A DCP

Supports D+ 1.2V D-1.2V Samsung 2.0A DCP

Charger

IP5209 integrates a synchronous constant-current and constant-voltage switching Li battery charger. When battery is below 3.0V, the charger is in trickle mode, and charging current is 100mA. When battery is above 3V, the charger turns to constant-current mode, and constant-voltage mode is used if battery voltage reaches 4.2V. When charge is over, recharge will begin if battery is below 4.1V.

IP5209's switching charger has a 1.6MHZ switching frequency, and its maximum charging current is 2.1A, charging efficiency is up to 97%, shortening 3/4 charging time in comparison with the normal chargers.

IP5209 integrates an adaptive power-path management system with priority to output load. It can charge batteries as well as cellphones at the same time.

IP5209's charger can adapt the charging current to the adapter of various load capacity, which can keep adapters away from malfunction.

Battery voltage selection

IP5209 can support different batteries by changing the connecting of VSET PIN. When VSET is floating, 4.2V battery is set. When VSET is connected to GND, 4.35V battery is set. When VSET is connected to VREG, 4.3V battery is set.

NTC

IP5209 integrated NTC, and can detect battery pack temperature.

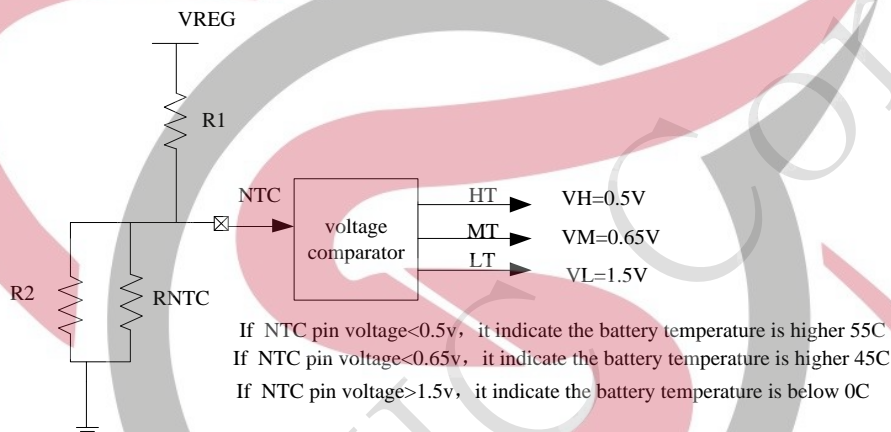


Fig 6 Battery NTC threshold

When NTC module detects the temperature is in 0~45° C, normal charging current is used. When temperature is in 45~55 ° C, half charging current is used. When temperature is above 55 ° C, charger is stopped.

Flash Light

IP5209 has an integrated MOS FET. LIGHT PIN in IP5209 can drive lighting LED directly. Maximum driving current is 100mA. When two short push is detected within 1s, lighting LED is opened or closed. If flash light is not needed, light should connect to GND, IP5209 will automatically close flash light.

VREG

VREG is an always on LDO with 50ma load capacity.

10 Typical application schematic

IP5209 only needs capacitors, resistors, and inductors to realize a full featured power bank solution.

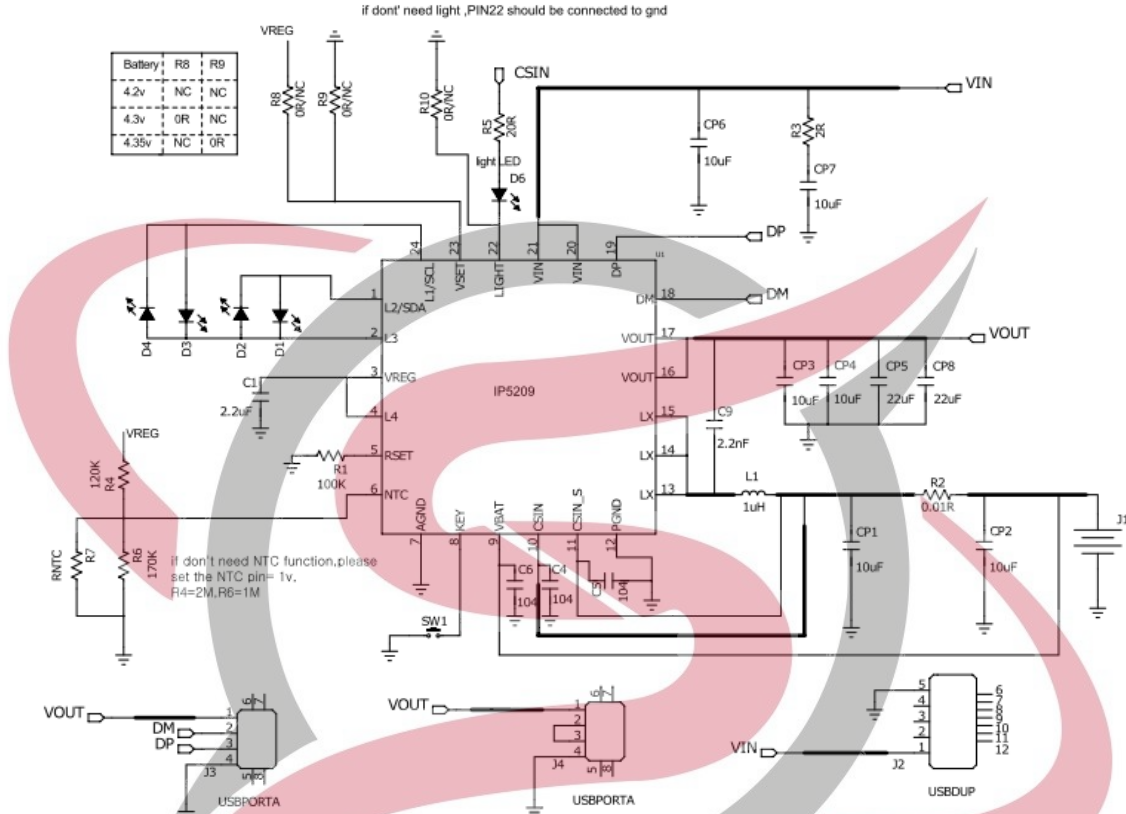
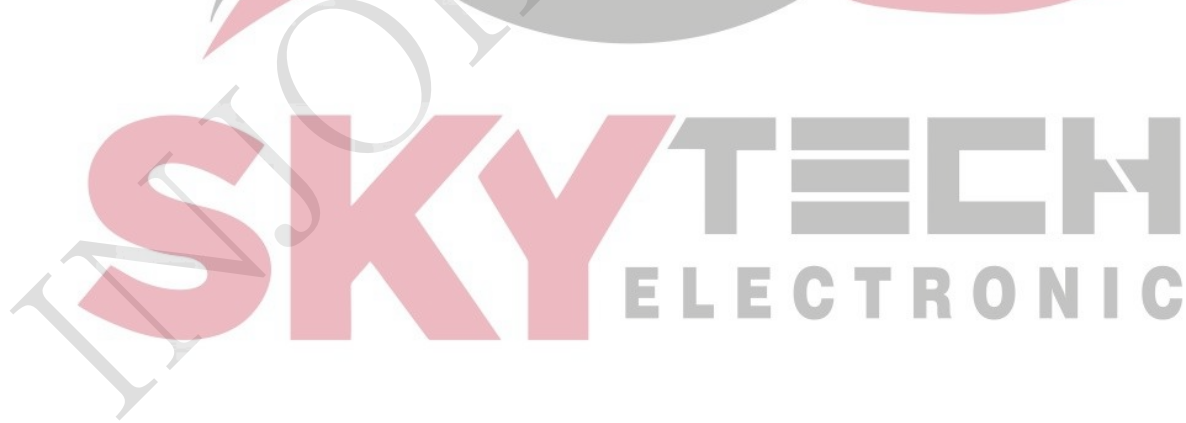


Fig 7 4 LEDs SOC indicator typical application schematic



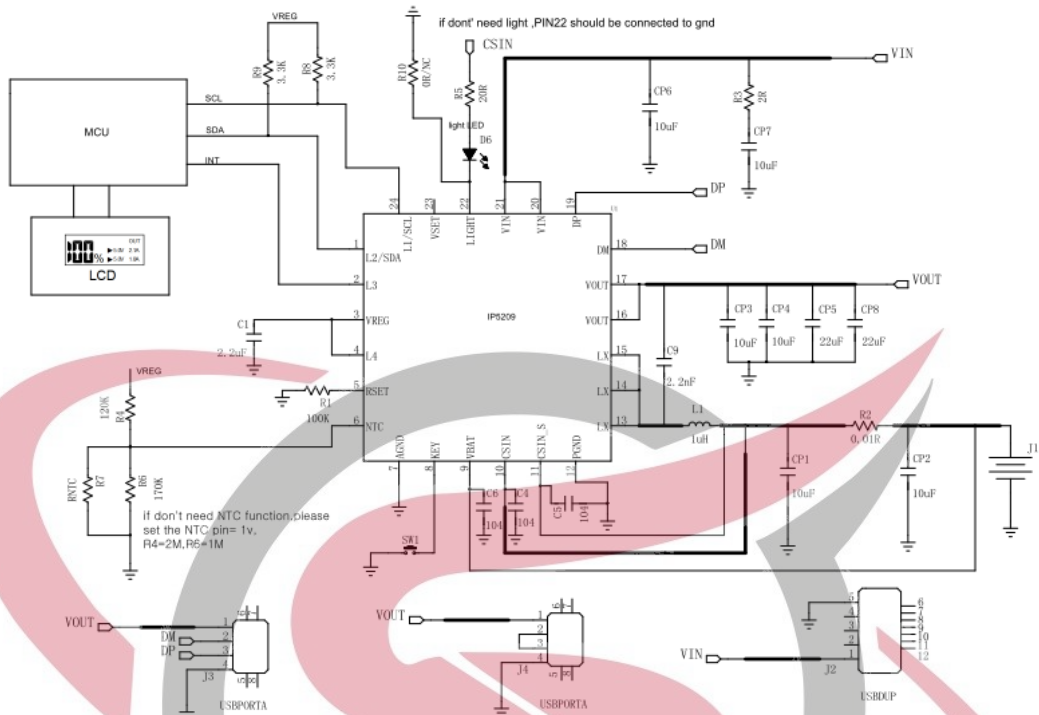


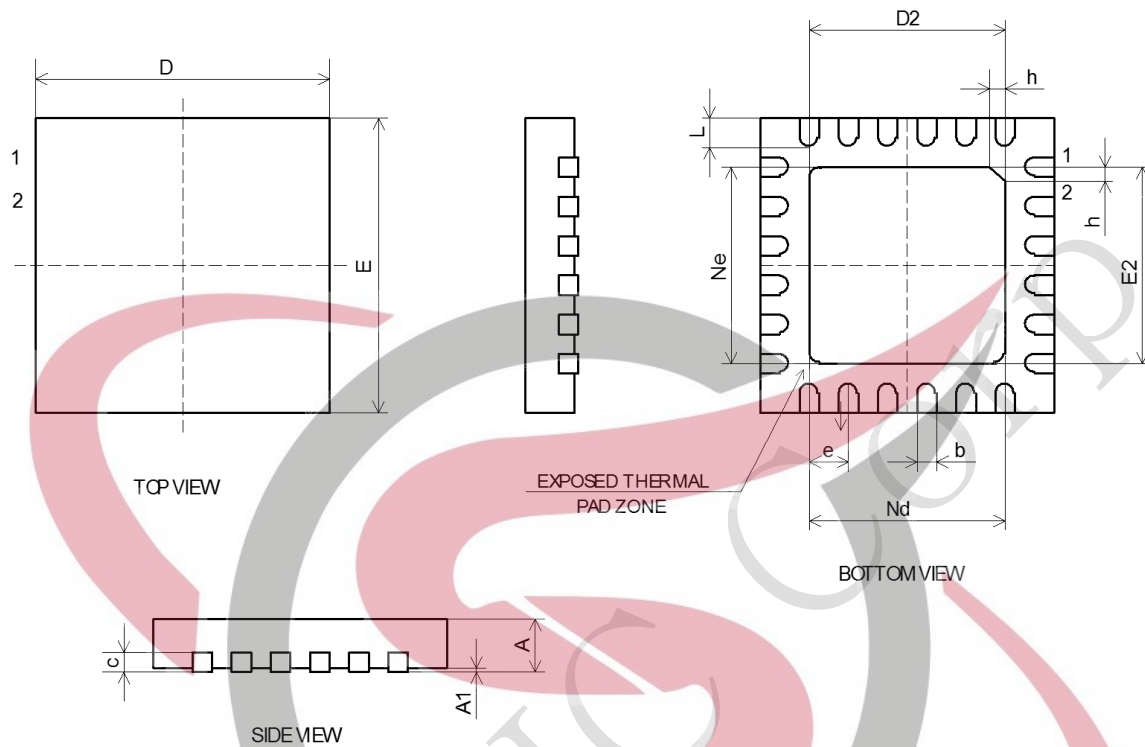
Fig 8 Typical application schematic with I2C

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11 BOM

index	Component name	Part number& spec	Unit	Num	Position	Note
1	IC	IP5209	PCS	1	U1	
2	SMD resistor	1206 0.01R 1%	PCS	1	R2	accuracy 1%, package size 1206
5	SMD resistor	0603 20R 5%	PCS	1	R5	R5 can be adjust the light LED brightness
6	SMD resistor	0603 2R 5%	PCS	1	R3	
7	SMD resistor	0603 100K 5%	PCS	1	R1	R1 can be used to adjust battery impedance
8	SMD resistor	0603 0R/NC	PCS	1	R8、R9、R10	
9	SMD resistor	0603 120K 5%	PCS	1	R4	
10	SMD resistor	0603 170K 5%	PCS	1	R6	
11	SMD resistor	0603 100K/25C, 1% NTC resistor	PCS	1	R7	If don't need NTC function, R7 NC
12	SMD resistor	0603 10UF 10%	PCS	6	CP1、CP2、CP3、 CP4、CP6、CP7	Ceramic capacitor rated voltage must be greater than 16v
13	electrolytic capacitor	0603 22UF 10%	PCS	1	CP5、CP8	
14	SMD capacitor	0603 104 10 %	PCS	3	C4、C5、C6	
15	SMD capacitor	0603 2.2UF 10%	PCS	1	C1	
16	SMD capacitor	0603 2.2nF 10%	PCS	1	C9	
17	SMD LED	0603	PCS	4	D1、D2、D3、D4	
18	Lighting LED	5mm	PCS	1	D6	
19	Inductor	SPM70701R0	PCS	1	L1	Isat, Idc >4.5A,DCR<0.01ohm,1u H @1.5MHz
20	USB socket	10mm 短体卷口	PCS	2	J3、J4	
21	Mini USB	Micro USB 母座 5脚 全贴	PCS	1	J2	
22	Push-button	6.5mm*5.1mm	PCS	1	SW1	
23	AC wire	2*100mm 红 黑	PCS	2	B+ B-	

12 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