IP5413P

TWS Bluetooth Earphone Charging Box SOC
integrated with 300mA charger and 200mA discharger

1. Features

- **Discharge**
  - ✧ 200mA Synchronous Boost Conversion
  - ✧ Up to 95%@5V/200mA discharge efficiency of synchronous switch
  - ✧ Built-in power path management supports charging and discharging at the same time
- **Charge**
  - ✧ Max 300mA linear charger, charging current can be customized
  - ✧ Adjusts charging current automatically to adapt to different load capacity adapters
  - ✧ Supports 4.20V, 4.30V 4.35V, 4.40V batteries.Standard product 4.20V, other voltages need to be customized
- **Battery indicators**
  - ✧ Supports 2/1 LED battery indicator
- **Low-power dissipation**
  - ✧ Automatically detect load plugged-in/ plugged-out/charger-end, Automatically enter standby mode
  - ✧ Standby power consumption up to 12uA minimum
- **Simplified BOM**
  - ✧ Built-in power MOS, only a few peripheral devices are needed in the complete charging and discharging scheme
- **Multiple protection, high reliability**
  - ✧ Output：over current and short circuit protection
  - ✧ Input：under voltage protection, over voltage protection and Battery over charged protection
  - ✧ Over temperature protection
  - ✧ Vin pin can withstand up to 10V(transient voltage)
  - ✧ ESD 2KV

2. Applications

- TWS Bluetooth Earphone Charging Box

3. Description

IP5413P is a multi-functional power management SOC for total solution on TWS Bluetooth Earphone Charging Box. It integrates with 5V boost converter, lithium battery charging management and battery level indicators.

IP5413P is highly integrated with abundant functions, support boost with one single inductor, which makes the total solution with minimized-size and low-cost BOM.

The synchronous 5V-boost system of IP5413P provides rated 200mA output current with conversion efficiency up to 95%,can support low-cost inductors and capacitors.

IP5413P's linear charger supplies max 300mA charging current. With the change of IC temperature and input voltage, IP5413P can automatically adjust the charging current.

IP5413P can detects the TWS earphone plug-in/plug-out in the Chargering Box independently. While the earphone is put in the Chargering Box, it enters the discharging mode automaticaly. When the earphone is fully charged, the Chargering Box automatically enters the sleep state, and the standby current can be reduced to 12uA.

IP5413P can support 2/1 LED battery indicator.
IP5413P is packaged with SOP8.

Contents

4. Reversion History

Note: Page numbers of previous editions may differ from those of the current edition.
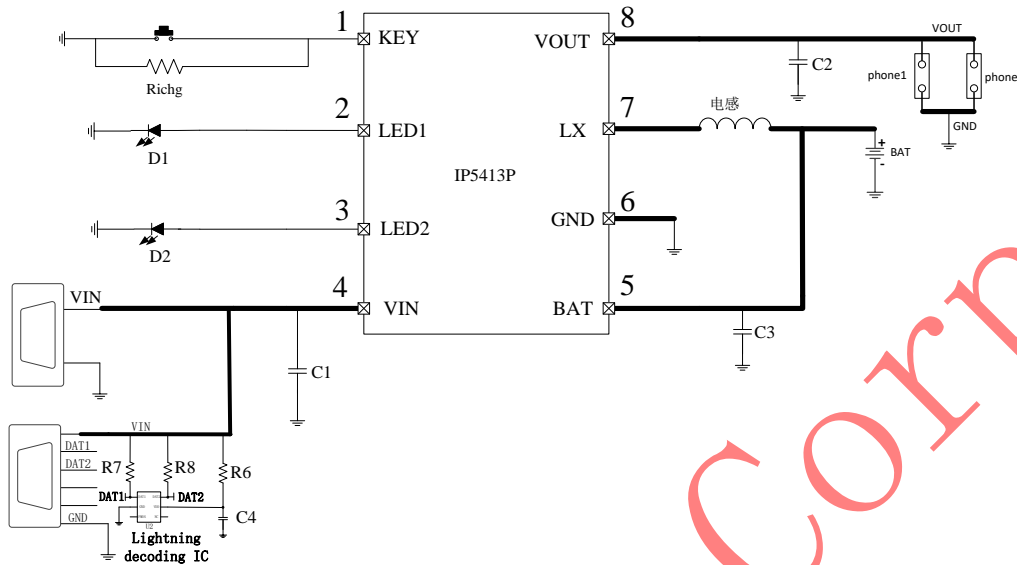
5. Simplified Application Schematic

Figure1   IP5413P Simplified Application Diagram

6. IP5413P IC Products List

IC part No.	Charging Current	Standby VOUT voltage	LED Mode	Key Mode	Light load shut down/ light off Time
IP5413P_BT_2D	200mA	2.4V	2	Single start Single close	8s
IP5413P_BT_2D_ISET	Setting by Richg	2.4V	2	Single start Single close	8s
IP5413P_CK_2D	200mA	5V	2	Single start	8s
IP5413P_CK_2D_ISET	Setting by Richg	5V	2	Single start	8s
IP5413P_BT_1D	200mA	2.4V	1	Single start Single close	8s
IP5413P_BT_1D_ISET	Setting by Richg	2.4V	1	Single start Single close	8s
IP5413P_CK_1D	200mA	5V	1	Single start	8s
IP5413P_CK_1D_ISET	Setting by Richg	5V	1	Single start	8s
IP5413P_BT_2D_P	200mA	2.4V	2	Single start Single close	8s
IP5413P_BT_1D_P	200mA	2.4V	1	Single start Single close	8s
IP5413P_BT_2D_ISET_P	Setting by Richg	2.4V	2	Single start Single close	8s

IP5413P_BT_1D_ISET_P	Setting by Richg	2.4V	1	Single start Single close	8s

Note:

1, "-2D" means 2-LED application; "-1D" indicates 1-LED application.

2. "-BT" means vout output 2.4V at standby; "-CK" means vout output 5.0V at standby.

3. "-P" indicates the identification threshold of plug-in/plug-out: 20ua/10ua for special headset application.
Plug-in/Plug-out identification threshold for other models: 10ua/5ua. There are 1-2ua errors for different battery voltages.

7. IP Series TWS Charging IC Products List

IC part no	Charge-discharge		Main features								
	discharge	charge	Wireless charging	LED	KEY	HALL	VSET	NTC	USB C	Package	
IP5513	300mA	IO option MAX 500mA	-	1/2/3/4/ digital tube	either-or		Customizable	Customizable	-	SOP16	
IP5516	300mA	IO option MAX 500mA	-	1/2/3/4/ digital tube	Support	Support	Customizable	Support	-	QFN16	
IP5518	300mA	IO option MAX 500mA	-	1/2/3/4/ digital tube	Support	Support	Customizable	Support	-	QFN24	
IP5518H	400mA	IO option MAX 500mA	-	1/2/3/4/ digital tube	Support	Support	Customizable	Support	-	QFN24	
IP6816	300mA	Customizable MAX 500mA	Support	1/2/3/4/ digital tube	Support	Support	Customizable	Support	-	QFN16	
IP6818	300mA	Customizable MAX 500mA	Support	1/2/3/4/ digital tube	Support	Support	Customizable	Support	-	QFN24	
IP5333	1A	IO option MAX 1A	-	1/2/3/4/ digital tube	Support	Support	IO option	Support	Support	QFN24	
IP5528	400mA	IO option MAX 1A	-	1/2/3/4/ digital tube	Support	Support	Customizable	Support	-	QFN28	
IP5416	200mA	MAX 300mA	-	1/2	Support	Support	Customizable	-	-	SOP8	
IP5428	300mA	MAX 1A	-	1/2	Support	Support	Customizable	-	-	SOP8	
IP5413T	200mA	MAX 300mA	-	1/2/4	Support	-	Customizable	-	-	SOP8	
IP5427	300mA	MAX 1A	-	1/2/4	Support	-	Customizable	-	-	SOP8	
IP5521	300mA	ICHG option MAX 500mA	-	1/2/3/4	Support	Support	VSET option	Support	-	QFN16 3mm*3mm	
IP5413V	200mA	Max 500mA	-	1/2/4	Support	-	Support	-	-	SOP8	
IP5413P	200mA	Max 300mA	-	1/2	Support	-	Support	-	-	SOP8	

"-" indicates that this function is not supported

8. Pin Definition

SOP8
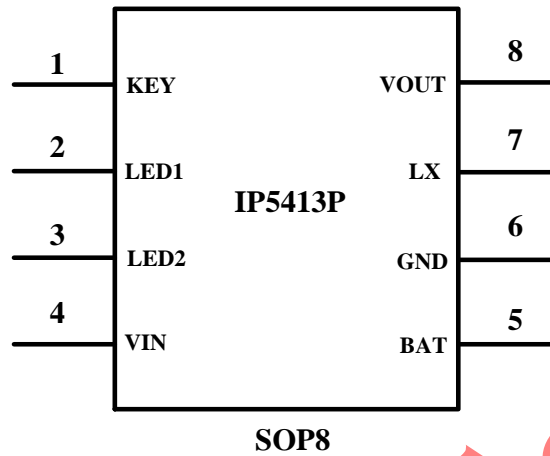
Figure2   IP5413P Pin Assignments

8.1. Pin description

Pin Num	Pin Name	Description
1	KEY	Key,reused as adjust charging current function
2	LED1	LED driver pin1
3	LED2	LED driver pin2
4	VIN	5V input pin
5	BAT	Battery charging pin, connected to the battery positive
6	GND	Ground
7	LX	DCDC switch node
8	VOUT	Boost 5V output

9. System Diagram
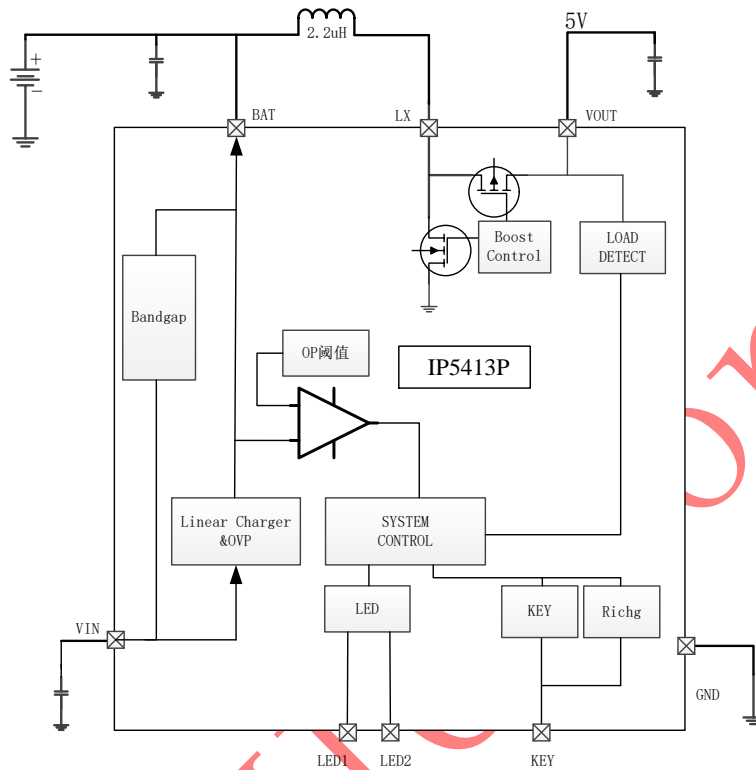
Figure3   IP5413P Internal System Diagram

10. Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Input Voltage Range	V_{IN}	-0.3 ~ 10	**V**
Junction Temperature Range	T_J	-40 ~ 150	℃
Storage Temperature Range	Tstg	-60 ~ 150	℃
Thermal Resistance (Junction to Ambient)	θ_{JA}	90	℃/**W**
ESD (Human Body Model)	ESD	2	**KV**

*Stresses beyond these listed parameter may cause permanent damage to the device.

Exposure to Absolute Maximum Rated conditions for extended periods may affect device reliability.

11. Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input Voltage	V_{IN}, V_{BUS}	4.5	5	5.7	V
Operating Temperature	T_A	-20	--	85	℃

*Device performance cannot be guaranteed when working beyond these Recommended Operating Conditions.

12. Electrical Characteristics

Unless otherwise specified, TA=25℃，L=2.2uH

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Charging System						
Input Voltage	V_{IN}	VBAT=3.7V	4.5	5	5.8	V
Input under voltage	V_{INUV}	VBAT=3.7V		4.5		V
Input Over Voltage	V_{INOV}	VBAT=3.7V	5.7	5.8	6.0	V
Constant Charge Voltage	$CV_{4.2V}$	4.2V battery	4.18	4.20	4.24	V
	$CV_{4.30V}$	4.3V battery	4.28	4.30	4.34	V
	$CV_{4.35V}$	4.35V battery	4.33	4.35	4.4	V
	$CV_{4.4V}$	4.4V battery	4.38	4.40	4.44	V
Recharge Voltage Threshold	VRCH	BAT voltage	4.10		4.15	V
Charge Stop Current	$Ivin_{stop}$	VIN=5V		25	40	mA
Charge Current	I_{VIN}	VIN=5V, VBAT=3.7V,Iset=300mA	270	300	330	mA
Trickle Charge Current	I_{TRKL}	VIN=5v,BAT=2.7v,Iset=300mA		50	60	mA
Trickle Charge Stop Voltage	V_{TRKL}		2.9	3	3.1	V
Charge Cut-Off Time	T_{END}		20	24	28	Hours
Boost System						
BatteryOperation Voltage	V_{BAT}		3.1	3.7	4.4	V
Low Power Shutdown Voltage	V_{BATLOW}	IOUT=200mA	2.8	2.9	3.0	V
DC Output Voltage	V_{OUT}	VBAT=3.7V @0A	5.05	5.15	5.25	V
		VBAT=3.7V @200mA	5.0	5.05	5.15	V

Output Voltage Ripple	ΔV_{OUT}	VBAT=3.0V~4.4V @200mA	50	100	150	mV
Boost Output Current	I_{vout}	VBAT=3.0V~4.4V	0		200	mA
Boost Overcurrent Shut Down Threshold	I_{shut}	VBAT=3.0V~4.4V	0.4		0.8	A
Light Load Shutdown threshold	I_{PLOUT}	VBAT=3.7V, The load current must be less than Iplout to shut down.		4		mA
Load Over Current Detect Time	T_{UVD}	Duration of output voltage under 4.2V		30		ms
Load Short Circuit Detect Time	T_{OCD}	Duration of output voltage under Battery voltage		20		us
Control System						
Switch Frequency	fs	Discharge switch frequency	0.8	0.9	1.0	MHz
PMOS On Resistance	r_{DSON}			450		mΩ
NMOS On Resistance				550		mΩ
Battery Input Standby Current 1	I_{STB}	VIN=0V,VBAT=3.7V,VOUT=2.4V/0V		12		uA
		VIN=0V,VBAT=3.7V,VOUT=5.0V		23		uA
LED Driving Current	I_{LED}		4	6	8	mA
Light Load Shut Down Detect Time	T_{loadD}	Load current less than I_{PLOUT}		8	10	s
Short Press On Key Wake Up Time	$T_{OnDebounce}$		100		300	ms
Long Press On Key Wake Up Time	$T_{Keylight}$		2		3	s
Thermal Shut Down Temperature	T_{OTP}	Rising temperature	130	140	150	℃
Thermal Shut Down Hysteresis	ΔT_{OTP}		30	40	50	℃

13. Function Description

13.1. Boost

IP5413P integrates a boost dc-dc converter with 5V/200mA output. To avoid large rush current causing device failure , it is built in overcurrent, short circuit, overvoltage and over temperature protection function, ensuring the reliability and stability of system operation. According to the IC temperature, IP5413P boost system can intelligently adjust output current, ensuring the IC temperature is below the set temperature.
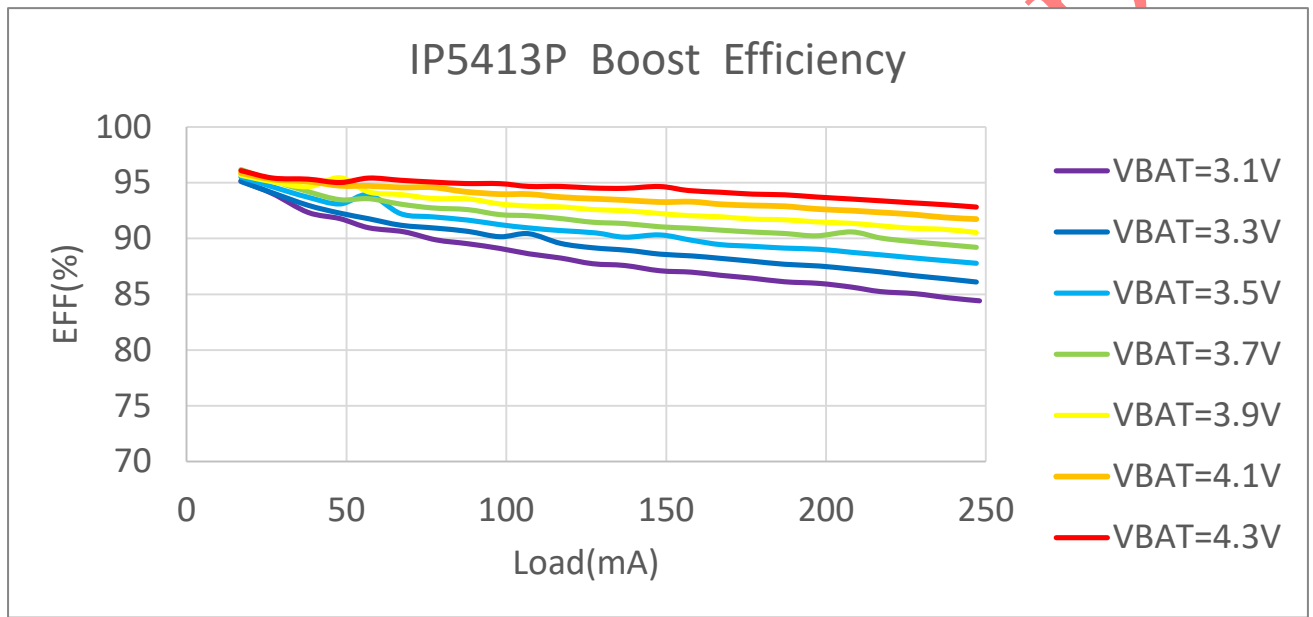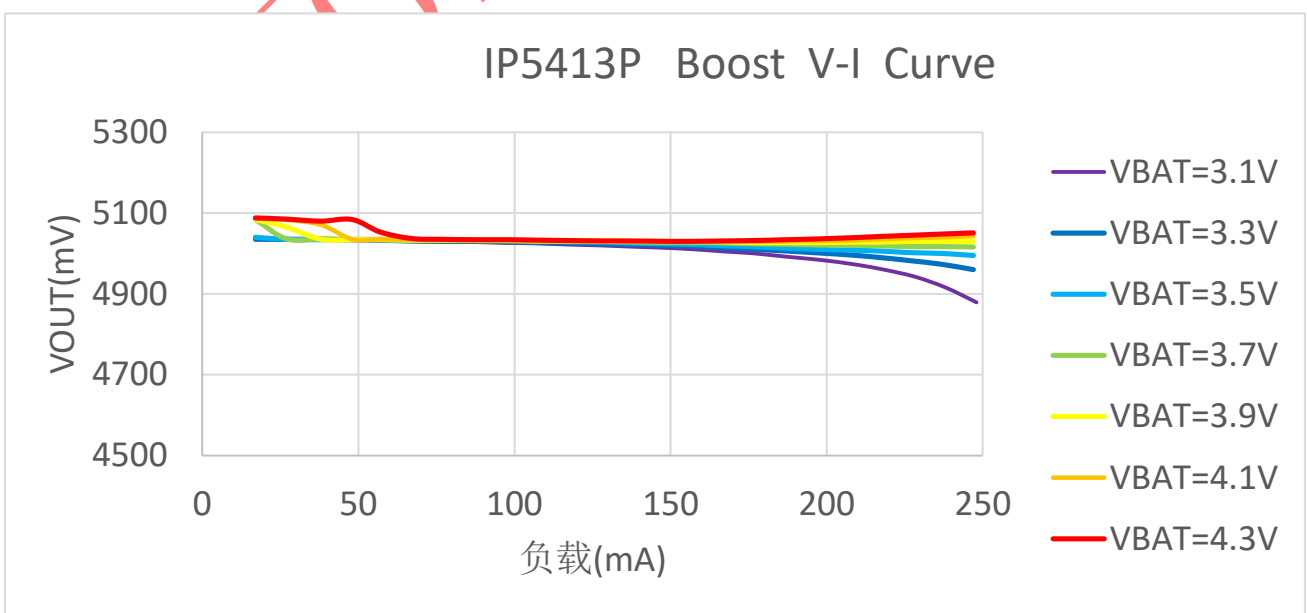

Figure4   IP5413P Boost Efficiency Curve

Figure5   IP5413P Boost Output V-I Curve

13.2. Charge

IP5413P integrates a linear lithium battery charger. When the battery voltage is less than 3V, precharge with 20mA+I_{set} *10%. When the battery voltage is greater than 3V, enter constant current CC charging. When the battery voltage is close to 4.2V/4.3V/4.35V/4.4V, enter constant voltage charging.

IP5413P supports max 300mA linear charging, According to the IC temperature and input voltage, IP5413P can intelligently adjust charging current.
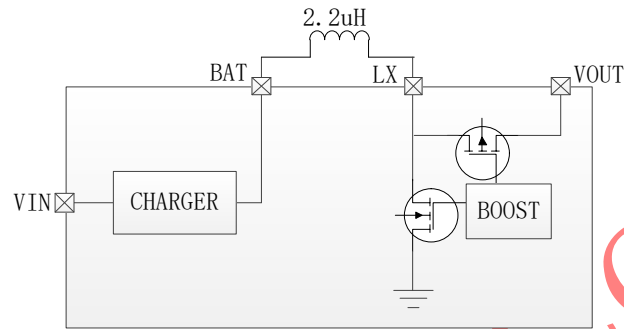
Figure6   IP5413P Power Path Diagram

13.3. Battery level display

IP5413P has a built-in power algorithm, which can accurately display the remaining battery power according to the cell capacity.

IP5413P can support 2/1 LED battery indicator.
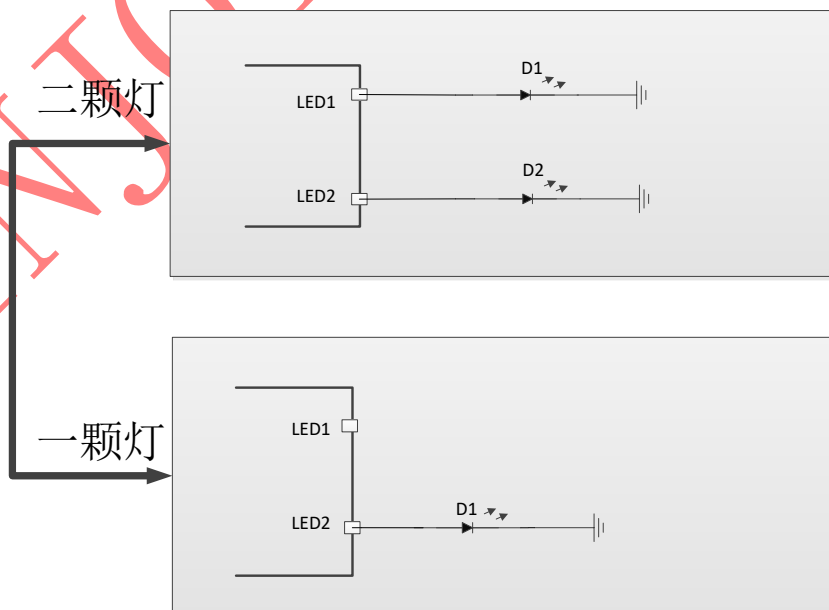
13.3.1. LED light display mode

Figure7   LED Mode Seleciton Circuit

■ IP5413P 2 LED Mode

	state	D1	D2
charge	charging	0.5Hz blink	off
	full	on	off
discharge	dischareging	off	on
	low	off	1Hz blink

■ IP5413P 1 LED Mode

	state	D1
charge	charging	0.5Hz blink
	full	on
discharge	dischareging	on
	low	1Hz blink

Note:

1. When VBAT is lower than 3.0V, press the button or insert the load, there is no light display function.

2. 1 LED mode and 2 LED mode can not be automatically identified, separate models are required.

3. 1 LED mode: no charging LED display when VBAT is lower than 2.5V, and the charging LED is displayed when VBAT is higher than 2.5V.

**   2 LED mode: the charging LED is displayed slightly when VBAT is lower than 2.5V, and the charging LED is displayed when VBAT is higher than 2.5V.**
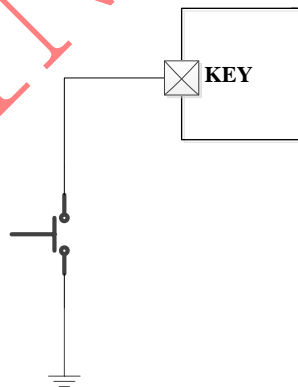
13.4. KEY function

Figure8   Key Circuit

■ Short press (pressed time in range of 100ms~2s): turn on the battery level display LED and BOOST output.

■ Long press (pressed time longer than 2s): No response.

Note: IP5413P "-BT" supports short press power on or power off by default; the "-CK" supports short press power on by default. If need to turn off the LED without power off function, please customize.

13.5. Set CC current by extern resistor

IP5413P can select the charging current by connecting different resistors on the KEY pin.

This Richg resistor cannot NC, otherwise the pin voltage sampling fails, which will lead to excessive charging current.
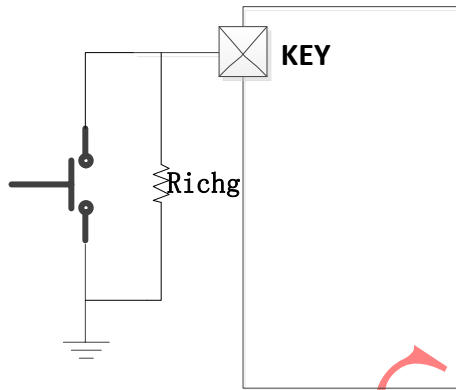

Figure9   Set I$_{CHG}$ Circuit

The recommended configuration of I$_{CHG}$ is as follows:

Richg Kohm	I$_{CHG}$
22K	150mA
47K	200mA
68K	250mA
100K	300mA

Note: only "-ISET" support Ichg function.

13.6. Plug-in/Plug-out detection

Once detecting the insertion of the earphone, the IP5413P wakes up from the standby mode and turns on the boost 5V to charge the earphone, eliminating the button operation and supporting the buttonless mold solution. The IP5413P supports light-load auto standby function. When the earphone's load current on VOUT are less than 4mA for 8 seconds, IP5413P will automatically enter standby mode.

When the earphones are charged end, IP5413P_BT series will enter standby mode and the VOUT output will change to 2.4V.

When the earphones are charged end, IP5413P_CK series will enter standby mode and the VOUT output will change to 5V.

14. Typical Application Diagram

Total solution of IP5413P charging Box is merely realized by passive devices of inductors, capacitors and resistors.
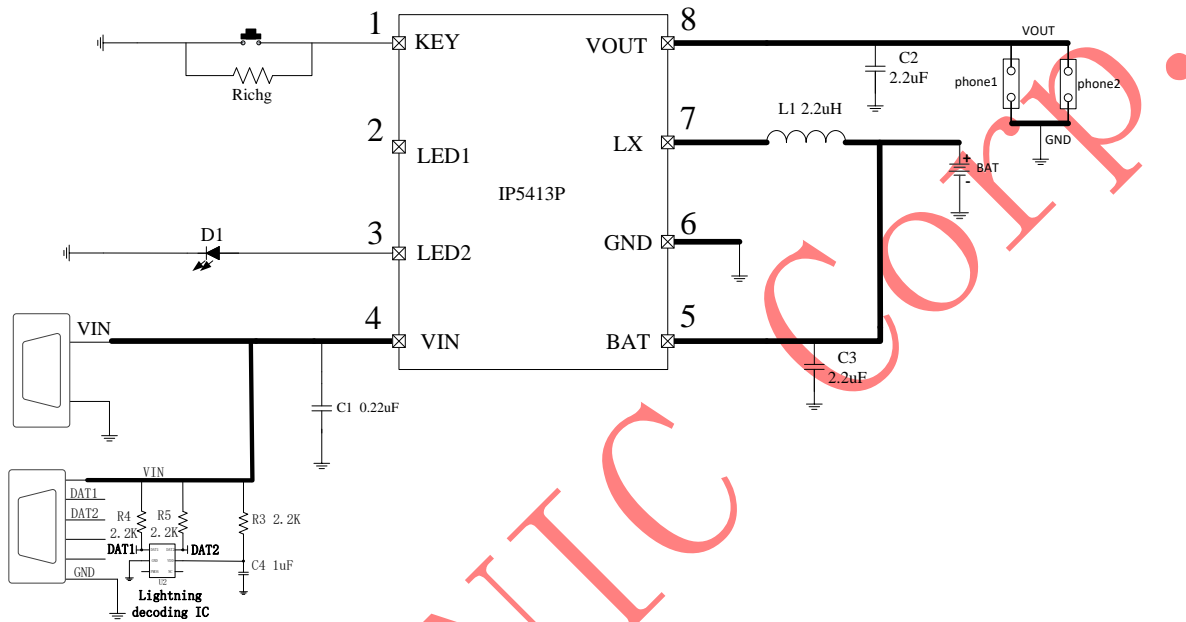
14.1. 1 LED mode typical application diagram

Figure10   1 LED Mode Typical Application Diagram
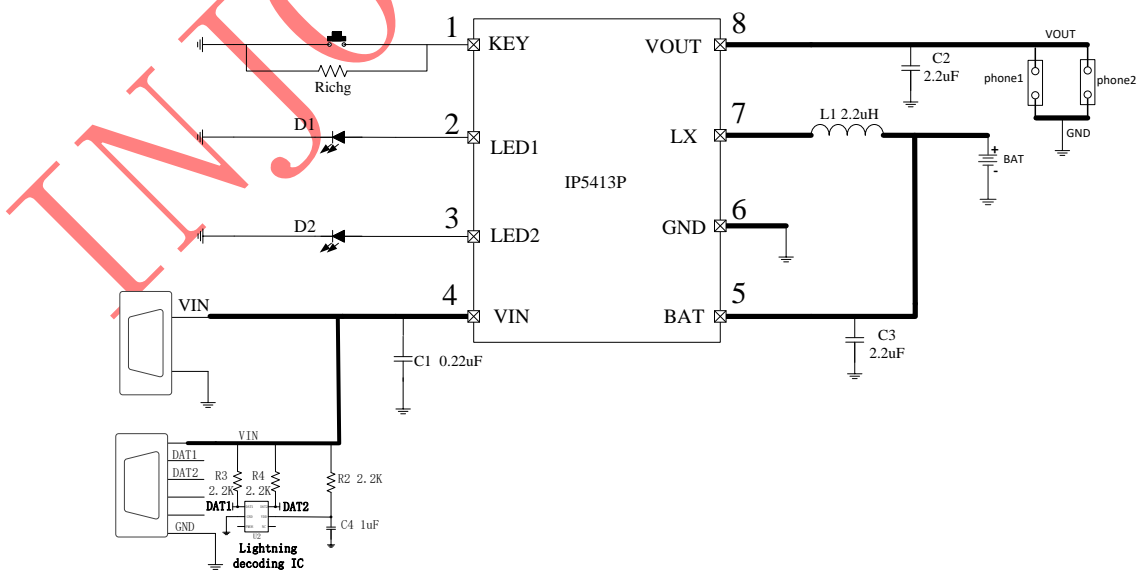
14.2. 2 LED mode typical application diagram

Figure11   2LED Mode Typical Application Diagram

14.3. Selection of peripheral devices

Specification of some components in typical application schematic diagram:

Device	Location	Parameter
C1	VIN capacitances	0.22μF/±10%/0603, withstanding voltage≥16V
Other Capacitances	Other position capacitance	0.22μF/±10%/0603, withstanding voltage≥10V
L1	Inductance	2.2Uh/±20% DCR<100mΩ Saturation current>2.5A

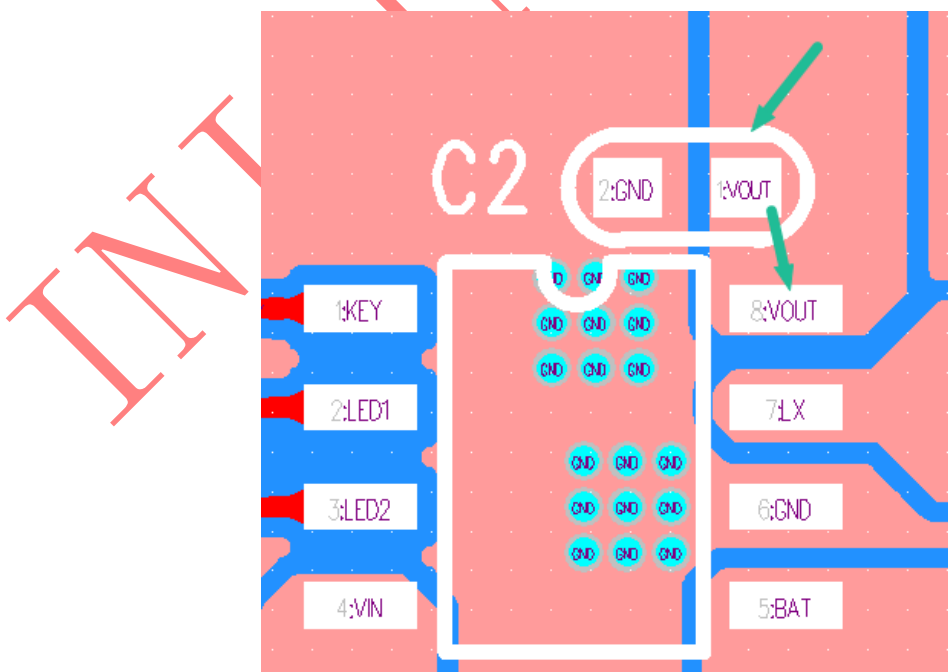## 15 PCB LAYOUT considerations

1. The capacitor at the VIN pin must be placed close to the VIN pin, and the ground loop should be as short as possible:
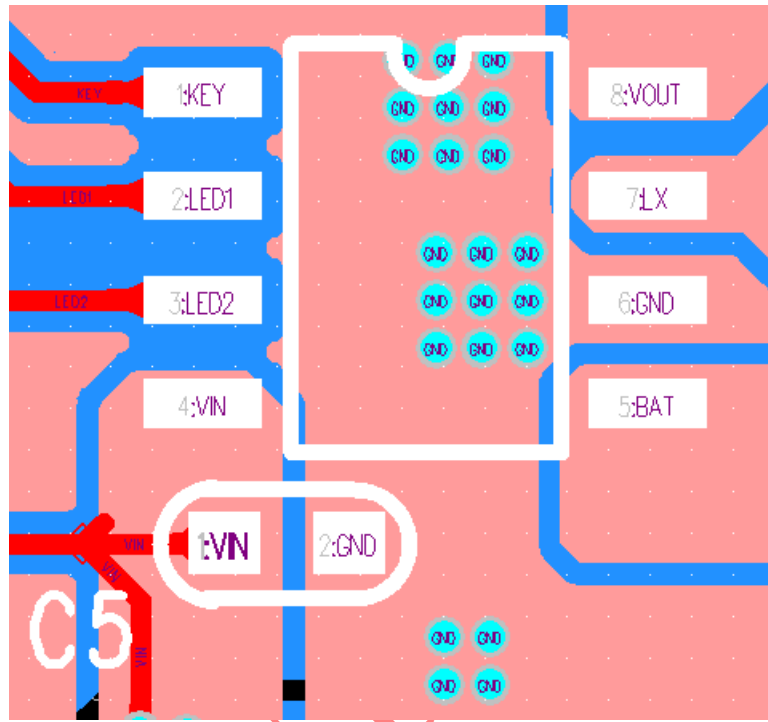
2. The capacitor at the Vout pin must be placed close to the Vout pin, and the ground loop should be as short as possible:

16. IC Mark description

IP5413P

XXXXXXXX

说明：
1、　　　--Injoinic Logo
2、IP5413P　--Part Number
3、XXXXXXXX　--Manufacture Number
4、　○　　--PIN1 Location

Figure12　IC Mark Description

17. Package

size mark	min(mm)	max(mm)	size mark	min(mm)	max(mm)
A	4.80	5.00	C3	0.05	0.20
A1	0.356	0.456	C4	0.203	0.233
A2	1.27TYP		D	1.05TYP	
A3	0.345TYP		D1	0.40	0.80
B	3.80	4.00	R1	0.20TYP	
B1	5.80	6.20	R2	0.20TYP	
B2	5.00TYP		θ1	17° TYP4	
C	1.30	1.60	θ2	13° TYP4	
C1	0.55	0.65	θ3	0° ～ 8°	
C2	0.55	0.65	θ4	4° ～ 12°	
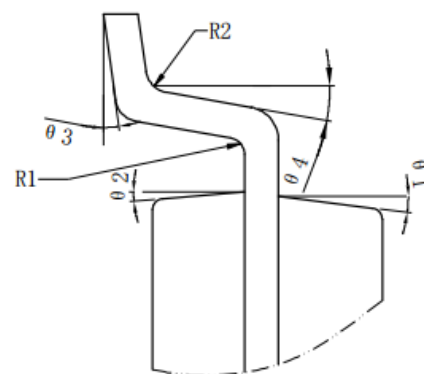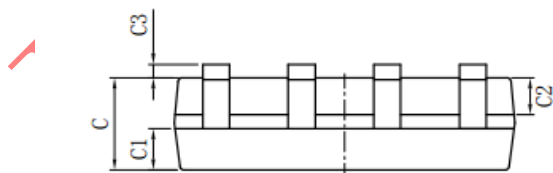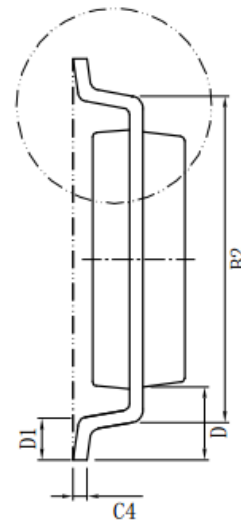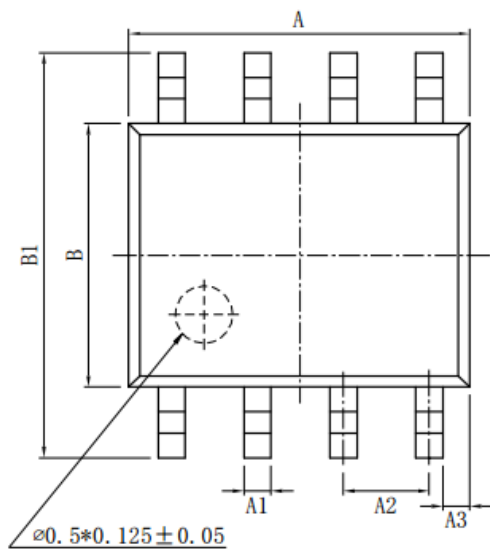
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