

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
- **Output enable**
 - ◇ Support output enable control, can be matched with HALL device
- **Low-power dissipation**
 - ◇ Automatically detect earphone 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: over voltage protection and Battery over charged protection

- ◇ Over temperature protection
- ◇ Vin pin can withstand up to 10V (transient voltage)
- ◇ ESD 2KV

- **Package: SOP8**

2. Applications

- TWS Bluetooth Earphone Charging Box ●

3. Description

IP5416P 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.

IP5416P 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 IP5416P provides rated 200mA output current with conversion efficiency up to 95%, can support low-cost inductors and capacitors.

IP5416P's linear charger supplies max 300mA charging current. With the change of IC temperature and input voltage, IP5416P can automatically adjust the charging current.

IP5416P can detect the TWS earphone plug-in/plug-out in the Charging Box independently. While the earphone is put in the Charging Box, it enters the charging mode automatically. When the earphone is fully charged, the Charging Box automatically enters the sleep state, and the standby current can be reduced to 12uA.

IP5416P can support 2/1 LED battery indicator.

IP5416P is packaged with SOP8.

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4. Reversion History

Note: Page numbers of previous editions may differ from those of the current edition.

Version V1.00 changed in February 2023		Page
• First Release.....		1
Version V1.00 changed to version V1.01 in June 2023		Page
• Chapter 6: Description of ISET products Charge Current Change.....		5
Version V1.01 changed to version V1.02 in July 2023		Page
• Chapter 6: Increased new products “_P”.....		5

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5. Simplified Application Diagram

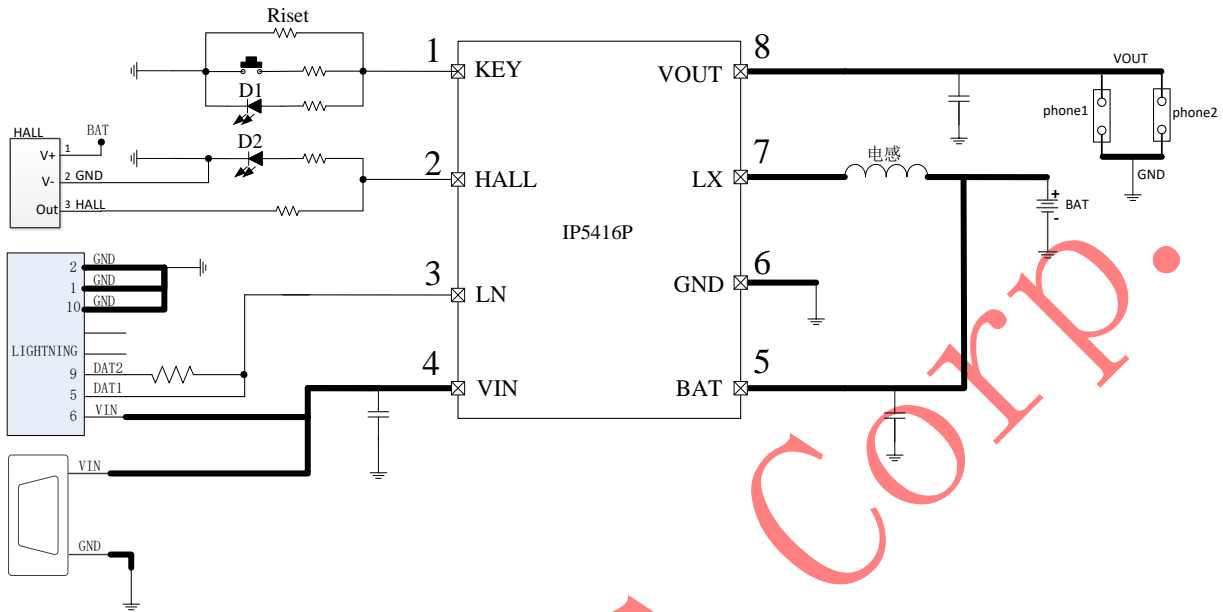


Figure1 IP5416P Simplified Application Diagram

6. IP5416P IC Products List

IC part No.	Charging Current	Standby VOUT voltage	LED Mode	Key Mode	Light load shut down/light off Time	HALL	lightning
IP5416P_BT_DET	200mA	2.4V	2	Single start Single close	Light load 8S shut down	Support	Support
IP5416P_BT 1D_DET	200mA	2.4V	1	Single start Single close	Light load 8S shut down	Support	Support
IP5416P_BT _DET_ISET	Setting by R_{iset}	2.4V	2	Single start Single close	Light load 8S shut down	Support	Support
IP5416P_BT 1D_DET_ISET	Setting by R_{iset}	2.4V	1	Single start Single close	Light load 8S shut down	Support	Support
IP5416P_BT _DET_P	200mA	2.4V	2	Single start Single close	Light load 8S shut down	Support	Support
IP5416P_BT 1D_DET_P	200mA	2.4V	1	Single start Single close	Light load 8S shut down	Support	Support
IP5416P_BT _DET_ISET_P	Setting by R_{iset}	2.4V	2	Single start Single close	Light load 8S shut down	Support	Support
IP5416P_BT _1D_DET_ISET_P	Setting by R_{iset}	2.4V	1	Single start Single close	Light load 8S shut down	Support	Support

Note:

1. “_BT” represents 2LED application, with a standby output of 2.4V; “_BT_1D” represents 1LED application, with a standby output of 2.4V;
2. “_P” indicates the recognition threshold for earphone plugged-in/plugged-out: 20uA/10uA, for special earphone applications. Other products of the recognition threshold for earphone plugged-in/plugged-out: 10uA/5uA. Different battery voltages have 1-2uA error.

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
IP6818H	400mA	IO option MAX 500mA	Support	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 500mA	-	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	Richg option MAX 500mA	-	1/2/3/4	Support	Support	Rvset option	Support	-	QFN16 3mm*3mm
IP5413V	200mA	MAX 500mA	-	1/2/3/4	Support	-	Customizable	-	-	SOP8
IP5413P	200mA	MAX 300mA	-	1/2	Support	-	Customizable	-	-	SOP8
IP5416P	200mA	MAX 300mA	-	1/2	Support	Support	Customizable	-	-	SOP8

"-" indicates that this function is not supported

8. Pin Definition

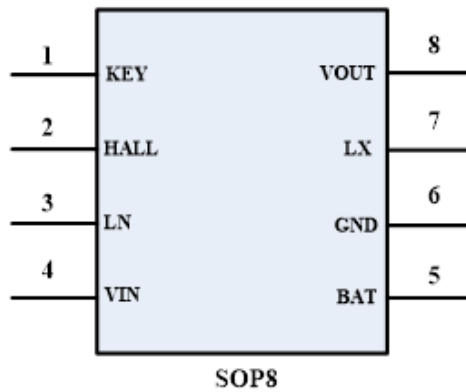


Figure2 IP5416P Pin Assignments

8.1 Pin Description

Pin Num	Pin Name	Description
1	KEY	Key, reused as drive LED1 function
2	HALL	HALL switch output signal, reused as drive LED2 function
3	LN	Lightning decoding pin
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. Function Description

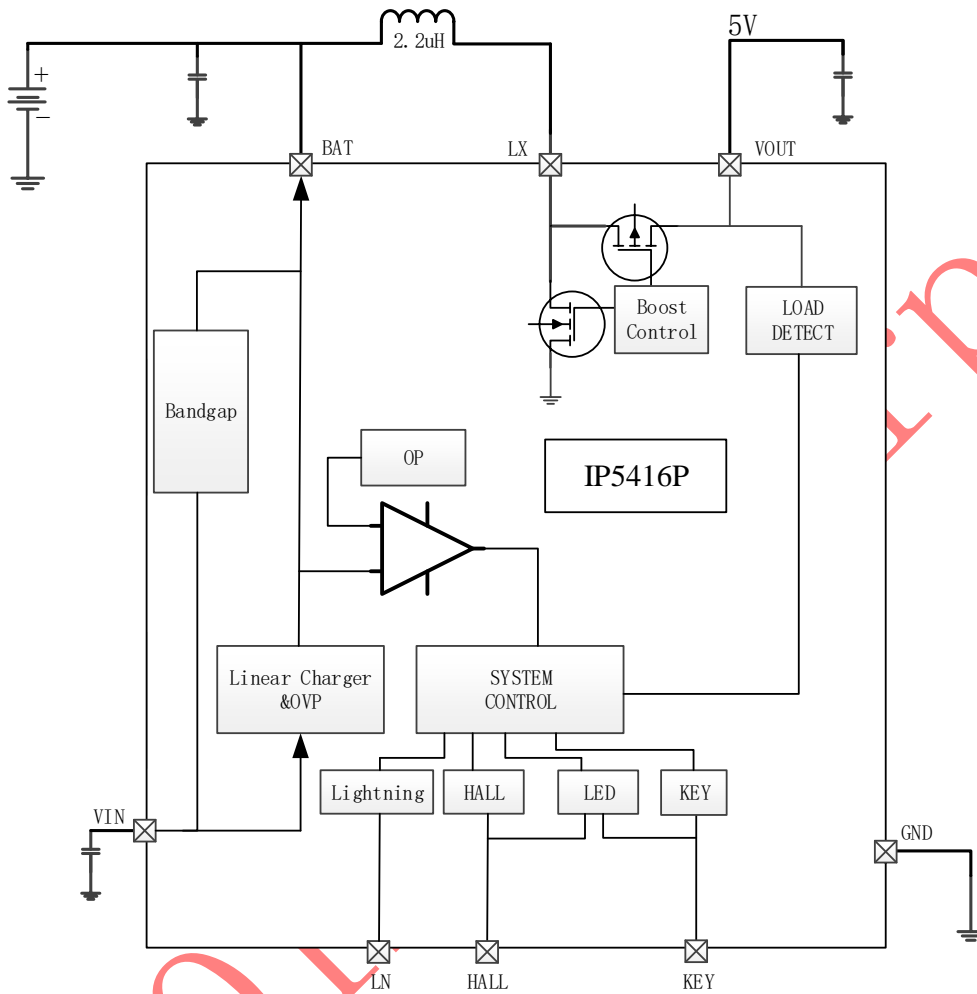


Figure3 IP5416P Internal System Diagram

10. Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Input Voltage Range	V_{IN}	-0.3 ~ 10	V
Junction Temperature Range	T_J	-40 ~ 150	°C
Storage Temperature Range	T_{stg}	-60 ~ 150	°C
Thermal Resistance (Junction to Ambient)	θ_{JA}	90	°C/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}	4.5	5	5.8	V
Operating Temperature	T_A	-20	--	85	°C

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

12. Electrical Characteristics

Unless otherwise specified, TA=25°C, L=2.2uH

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Charging System						
Input Voltage	V _{IN}	V _{BAT} =3.7V	4.5	5	5.8	V
Input under voltage	V _{INUV}	V _{BAT} =3.7V		4.5		V
Input Over Voltage	V _{INOV}	V _{BAT} =3.7V		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	V _{RCH}	After fully charged, reduce V _{BAT} and note the BAT voltage when recharging	4.10		4.15	V
Charge Stop Current	I _{VINstop}	V _{IN} =5V	20		40	mA
Charge Current	I _{VIN}	V _{IN} =5V, V _{BAT} =3.7V, I _{set} =200mA	170	200	230	mA
Trickle Charge Current	I _{TRKL}	V _{IN} =5V, V _{BAT} =2.7V, I _{set} =200mA		40		mA
Trickle Charge Stop Voltage	V _{TRKL}		2.95	3.05	3.15	V
Charge Cut-Off Time	T _{END}		20	24	28	Hours
Boost System						
Battery Operation Voltage	V _{BAT}		3.1	3.7	4.4	V
Low Power Shutdown Voltage	V _{BATLOW}	I _{OUT} =200mA		2.9	3.0	V
DC Output Voltage	V _{OUT}	V _{BAT} =3.7V @0A	5.05	5.15	5.25	V
		V _{BAT} =3.7V @200mA	5.0	5.05	5.15	V
Output Voltage Ripple	ΔV _{OUT}	V _{BAT} =3.0V~4.4V @200mA	50	100	150	mV
Boost Output Current	I _{VOUT}	V _{BAT} =3.0V~4.4V	0		200	mA
Boost Overcurrent Shut Down Threshold	I _{SHUT}	V _{BAT} =3.0V~4.4V	0.4		0.85	A
Light Load Shutdown Threshold	I _{PLOUT}	V _{BAT} =3.7V, the load current of both headphones must be less		5		mA

		than $I_{P_{L_{OUT}}}$ to shut down				
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	I_{STB}	$V_{IN}=0V, V_{BAT}=3.7V, V_{OUT}=2.4V$		12		uA
LED Driving Current	I_{LED}		4	6	8	mA
Light Load Shut Down Detect Time	T_{loadD}	Load current less than $I_{P_{L_{OUT}}}$		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	°C
Thermal Shut Down Hysteresis	ΔT_{OTP}		30	40	50	°C

13. Function Description

13.1 Boost

IP5416P 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, IP5416P boost system can intelligently adjust output current, ensuring the IC temperature is below the set temperature.

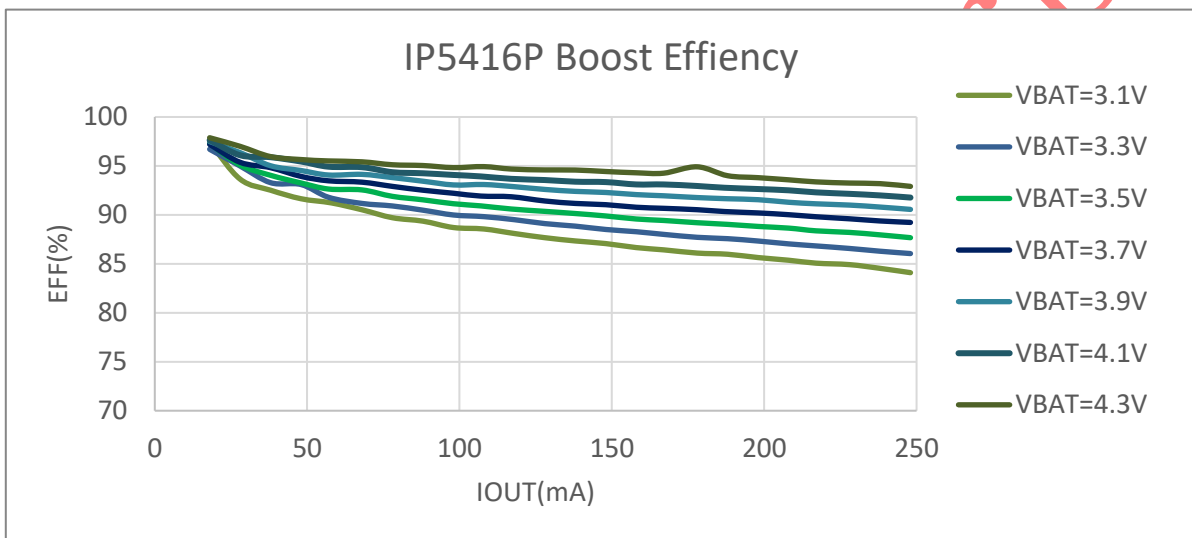


Figure4 IP5416P Boost Efficiency Curve

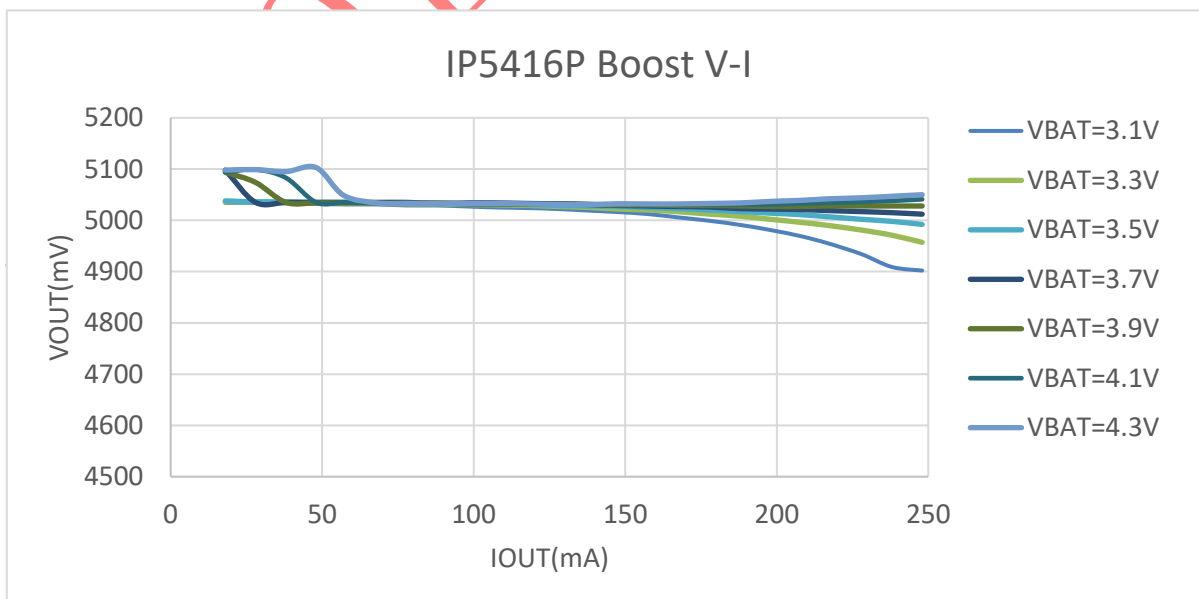


Figure5 IP5416P Boost Output V-I Curve

13.2 Charge

IP5416P integrates a linear lithium battery charger. When the battery voltage is less than 3V, precharge with $20\text{mA} + I_{\text{set}} * 10\%$. 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.

IP5416P supports max 300mA linear charging. According to the IC temperature and input voltage, IP5416P can intelligently adjust charging current.

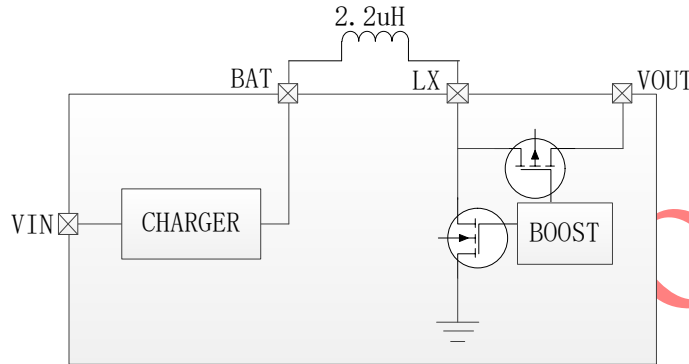


Figure6 IP5416P Power Path Diagram

13.3 Battery Level Display

IP5416P has a built-in power algorithm, which can accurately display the remaining battery power according to the cell capacity.

IP5416P can support 2/1 LED battery indicator.

13.3.1 LED Light Display Mode

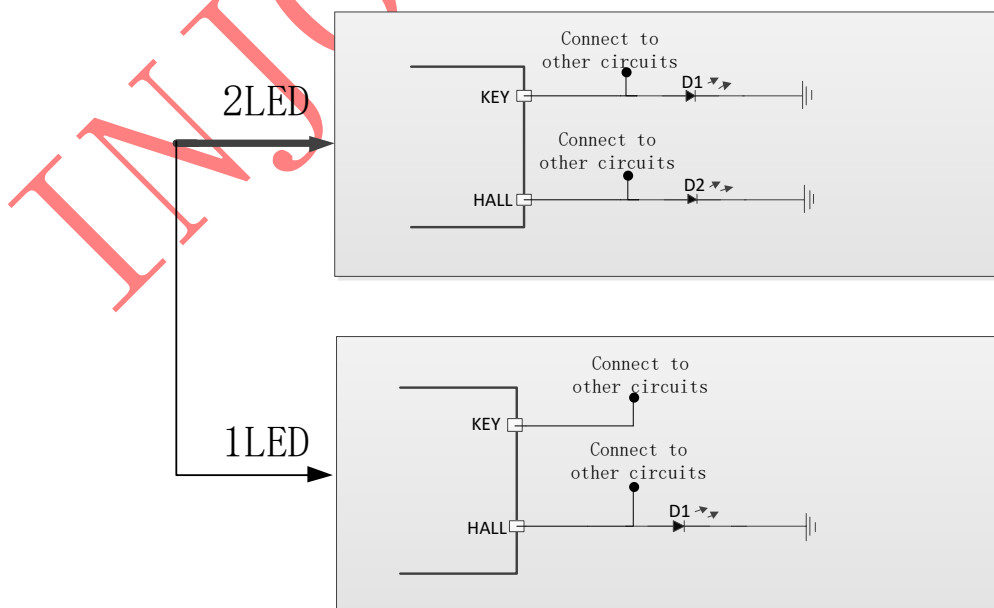


Figure7 LED Mode Selection Circuit

Note: IP5416P can't automatically identify 1/2 LED modes, 1/2 LED modes needs to be customized separately.

■ 2 LED Mode

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

■ 1 LED Mode

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

■ Light Display Description

	HALL state	Earphone in or out	Light Display State
charge	HALL keep turning on or keep turning off		Show charge light display
	HALL from open to closed		Keep charge light display
	HALL from closed to open		Keep charge light display
discharge	HALL from open to closed	in	Show discharge light display
		out	No light display
	HALL from closed to open		Show discharge light display 8s

Note:

1. "Charge light display" and "discharge light display" in IP5416P "Light Display Description" list mean that the light display description in "2 LED Mode" and "1 LED Mode".
2. When discharging and HALL from open to closed, IP5416P will determine the earphone in or out: If earphone in, IP5416P will show discharge light display, discharge light on when charging, discharge light off when fully charged. If earphone out, IP5416P will have no light display when HALL from open to closed.

13.4 KEY Function

IP5416P support single start, single close. If single shutdown function is needed, it can be customized.

- 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.

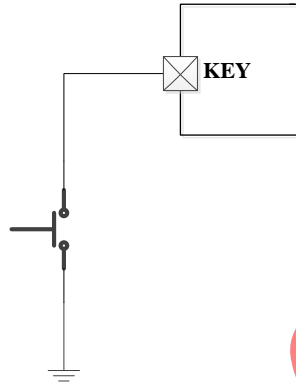


Figure8 Key circuit

13.5 Setting Constant Charge Current By External Resistance

IP5416P can select the constant current charging current of the battery by connecting different resistors on the KEY pin.

This Riset resistor can't be NC, otherwise the sampling of the KEY pin voltage will fail, which can cause excessive charge current.

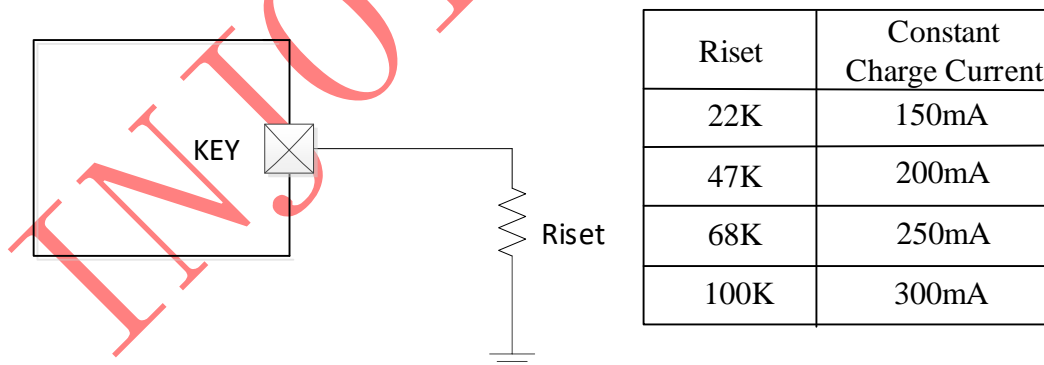


Figure9 Constant Charge Current Setting Circuit

Note: Only “_ISET” Products support this current.

13.6 HALL Function

IP5416P can identify the change of output level of HALL device and control the VOUT output. When earphone charging box is open, the earphone automatically turns on and connects back to the mobile phone.

- The signal level types of HALL devices supported by IP5416P standard models are: when the earphone charging box is opened, HALL outputs high level; when the earphone charging box is closed, HALL outputs low level.

When HALL level is high: VOUT output 0V, earphone starts automatically.

When HALL level is low: VOUT output 2.4V, when IP5416P detects earphone in, VOUT rise to 5V, and earphone is charging.

- For other types of HALL devices, please contact the injoinic technical support department.

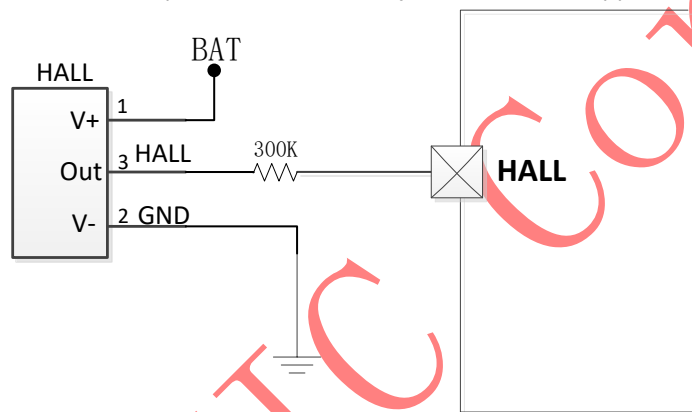


Figure9 HALL circuit

13.7 Light Load Standby Instructions

HALL changes from high level to low level (Earphone charging box close), the VOUT output will open and rise to 5V for earphone charging. When the earphone is fully charged, IP5416P automatically enters the sleep state.

When the earphones are charged end, “_BT” products will enter standby mode and the VOUT output will change to 2.4V.

HALL changes from low level to high level (Earphone charging box open), IP5416P automatically close output and plug-in/plug-out detection.

14. Typical Application Diagram

Total solution of IP5416P charging Box is merely realized by passive devices of inductors, capacitors and resistors.

The value of R1 / R2 in the figure can be selected by the customer according to the brightness of the required LED.

14.1 1LED Mode Typical Application Diagram

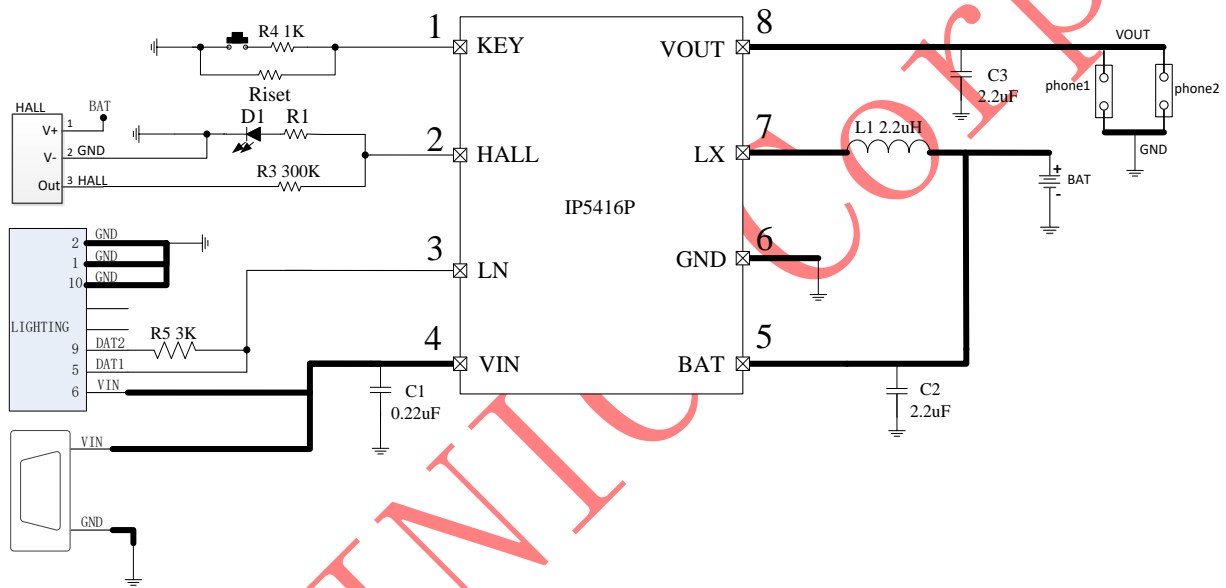


Figure11 IP5416P 1LED Mode Typical Application Diagram

14.2 2LED Mode Typical Application Diagram

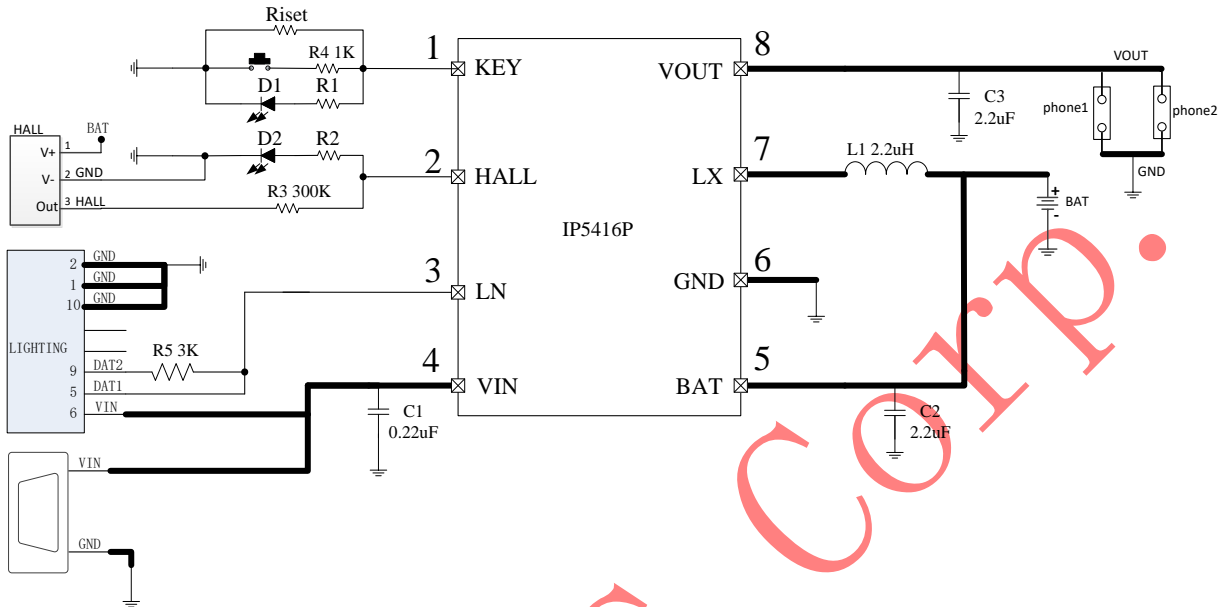


Figure12 IP5416P 2LED Mode Typical Application Diagram

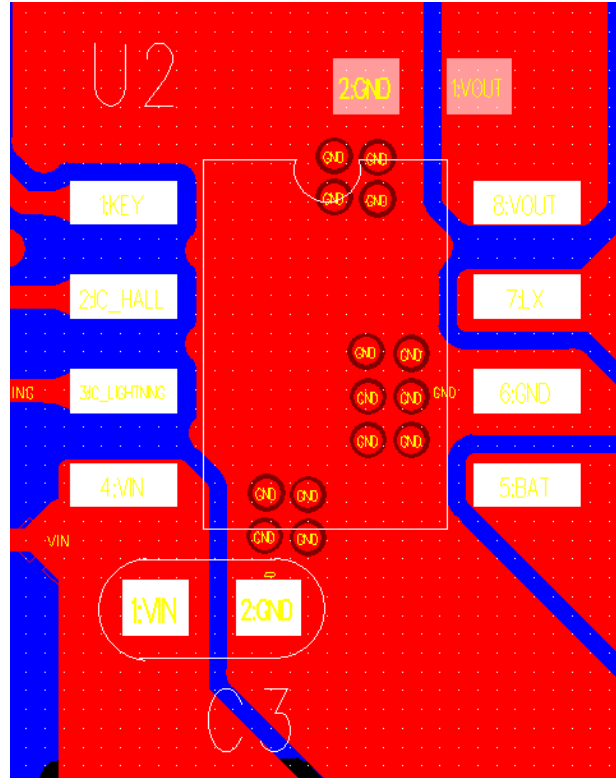
14.3 Selection Of Peripheral Devices

Device Parameter Requirements:

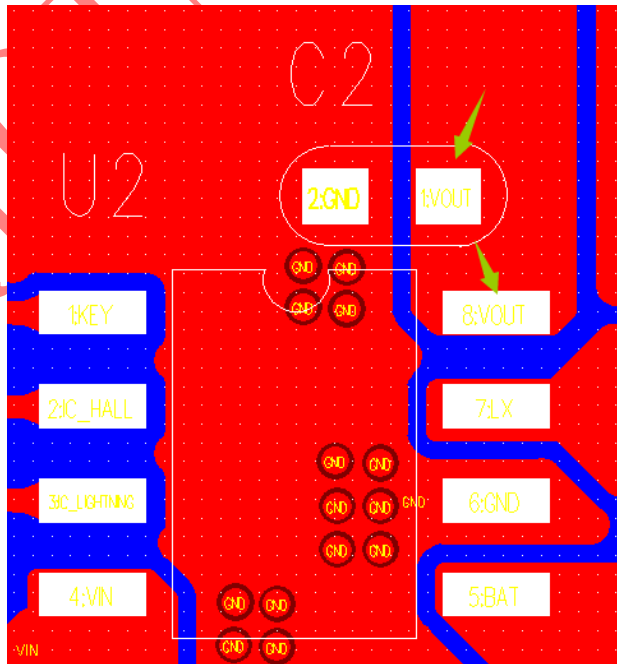
Device	Location	Parameter
C1	Capacitance of RC at VIN input	0.22uF/±10%/0603, withstanding voltage ≥16V
Other capacitance	Other capacitance	precision ±10%, withstanding voltage ≥16V
L1	Inductance	2.2uH/±20% DCR<100mΩ Saturation current>2.5A

15. PCB LAYOUT

- VIN capacitor should be placed close to VIN PIN, the ground loop should be as short as possible:



- VOUT capacitor placed close to the VOUT pin, the ground loop should be as short as possible:



16. IC Mark Description



Note:


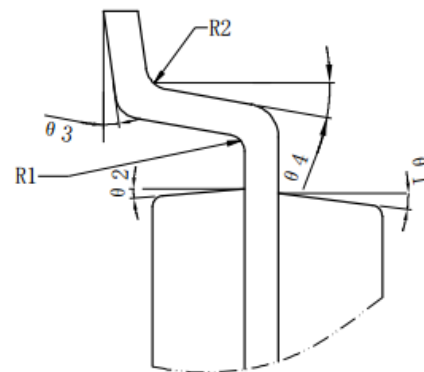
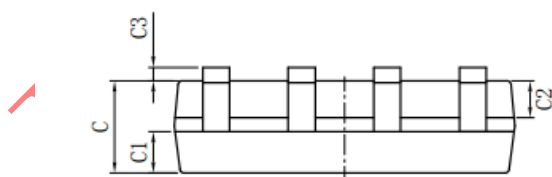
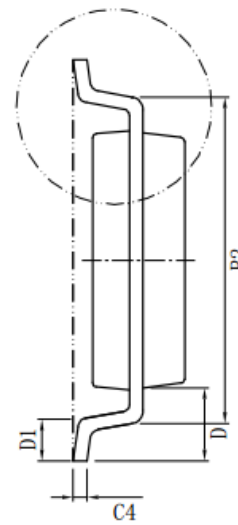
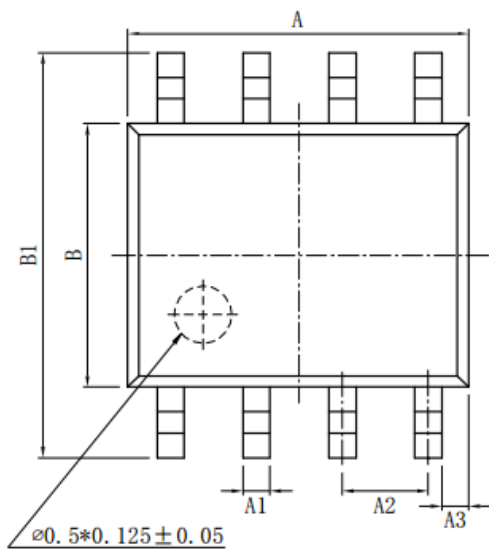
- 1、  --Injoinic Logo
- 2、 IP5416P --Part Number
- 3、 XXXXXXXX --Manufacture number
- 4、 ○ --PIN1 location

Figure13 IP5416P Mark Description

17. Package

标注	尺寸	最小 (mm)	最大 (mm)	标注	尺寸	最小 (mm)	最大 (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		θ 1		17° TYP4	
C		1.30	1.60	θ 2		13° TYP4	
C1		0.55	0.65	θ 3		0° ~ 8°	
C2		0.55	0.65	θ 4		4° ~ 12°	



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