

TWS Bluetooth Earphone Charging Box SOC integrated with Qi wireless power receiver

1. Features

- **Discharge**
 - ◇ Output capacity: 5V/300mA
 - ◇ Up to 93%@5V/150mA discharge efficiency of synchronous switch
 - ◇ Built-in power path management supports charging and discharging at the same time
- **Charge**
 - ◇ Max 500mA linear charger, adjustable charging current
 - ◇ Adjusts charging current automatically to adapt to different load capacity adapters
 - ◇ Supports 4.20V, 4.30V 4.35V, 4.40V batteries
 - ◇ Supports wireless power receiver compliant with Qi
- **Battery indicators**
 - ◇ Built-in 10bits ADC , accurate calculation of battery capacity
 - ◇ Supports 4/3/2/1 LED battery indicator
- **Low-power dissipation**
 - ◇ Automatically detect earphone plugged-in/plugged-out/charger-end, Automatically enter standby mode
 - ◇ Support detection of earphone plug-in/plug-out independly
 - ◇ Standby power consumption up to 25ua 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 and Battery over charged protection
 - ◇ Over temperature protection
 - ◇ Vin pin can withstand up to 15V(transient voltage)
 - ◇ ESD 4KV

- **In-depth customization**
 - ◇ Flexible and low-cost customized program
- **Package: QFN16 (4*4*0.75mm)**

2. Applications

- TWS Bluetooth Earphone Charging Box
- Lithium Battery Portable Device

3. Description

IP6816 is a multi-functional power management SOC for total solution on TWS Bluetooth Earphone Charging Box. It integrates with Qi wireless power receiver, 5V-boost converter, lithium battery charging management and battery level indicators.

IP6816 is highly integrated with abundant functions, which makes the total solution size minimized and BOM costed down.

The synchronous 5V-boost system of IP6816 provides rated 300mA output current with conversion efficiency up to 93%. DC-DC converter operates at 1.5MHz, and can support low-cost inductors and capacitors.

IP6816's linear charging system supplies max 500mA charging current. With the change of IC temperature and input voltage, IP6816 can automatically adjust the charging current.

IP6816 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 discharging mode automatically. When the earphone is fully charged, the Charging Box automatically enters the sleep state, and the standby current can be reduced to 30uA. The earphone's charge-end current can be flexible and customizable, such as 4mA or 8mA.

IP6816 can support 1/2/3/4 LED battery indicator, The built-in 10bits ADC can accurately calculate the Charging Box's battery capacity.

IP6816 is packaged with QFN16(4*4*0.75mm).

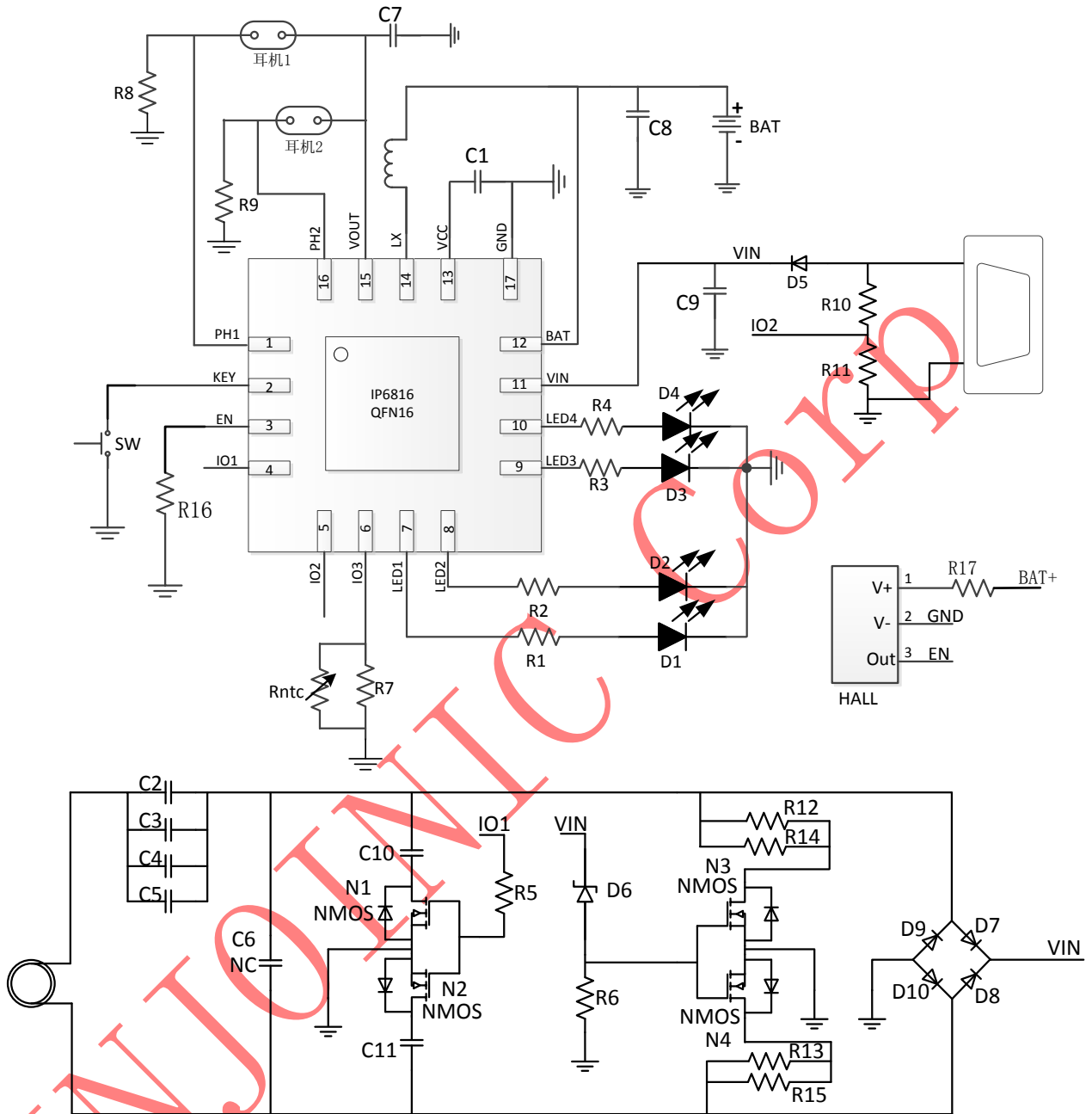


Figure1 IP6816 Simplified Application Diagram

4. Pin Definition

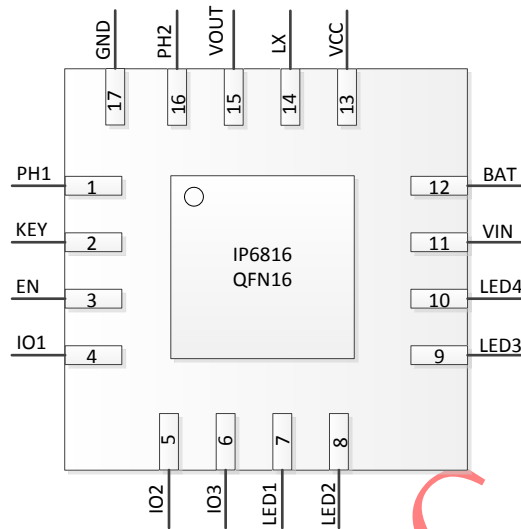


Figure 2 IP6816 Pin Assignments

Pin Num	Pin Name	Description
1	PH1	Earphone 1 negative
2	KEY	Key input
3	EN	HALL switch output signal , customization individually
4	IO1	Wireless power reception control pin
5	IO2	Wired/wireless charging recognition pin
6	IO3	NTC pin
7	LED1	LED driver pin1
8	LED2	LED driver pin2
9	LED3	LED driver pin3
10	LED4	LED driver pin4
11	VIN	5V input pin
12	VBAT	Battery voltage positive pin
13	VCC	LDO output pin, connect to 2.2uF inductor
14	LX	DCDC switch node
15	VOUT	Boost output
16	PH2	Earphone 2 negative
17	GND	System ground

5. IP Series Products List

	IC Part No.	LED Mode	Charging Current	Light-Load time	Key mode	Light-Load Current to enter standby	auto-wakeup supporting	always-5V supporting	Minimum order quantity
IP5303T series	IP5303T_BT_200MA	1/2	200mA	32 seconds	single start, double close	5mA	yes	no	4K
	IP5303T_BT_500MA	1/2	500mA	32 seconds	single start, double close	5mA	yes	no	4K
	IP5303T_500MA_S_NAT	1/2	500mA	32 seconds	single start, double close	5mA	no	no	4K
IP5305T series	IP5305T_BT	1/2/3/4	1A	32 seconds	single start, double close	5mA	yes	no	4K
	IP5305T_BT_500MA	1/2/3/4	500mA	32 seconds	single start, double close	5mA	yes	no	4K
	IP5305T_BT_300MA	1/2/3/4	300mA	32 seconds	single start, double close	5mA	yes	no	4K
	IP5305T_BT_8S	1/2/3/4	1A	8 seconds	single start, double close	5mA	yes	no	4K
	IP5305T_BT_8S_300MA	1/2/3/4	300mA	8 seconds	single start, double close	5mA	yes	no	4K
IP5403 series	IP5403_CK10_5M	4	500mA	36 seconds	single start, no key close	10mA	no	yes	4K
	IP5403_CK10_5M_D1D2	1/2	500mA	36 seconds	single start, no key close	10mA	no	yes	4K
	IP5403_CK10_2M	4	200mA	36 seconds	single start, no key close	10mA	no	yes	4K
	IP5403_CK10_2M_D1D2	1/2	200mA	36 seconds	single start, no key close	10mA	no	yes	4K
	IP5403_BT10_5M	4	500mA	36 seconds	single start, no key close	10mA	no	no	4K
	IP5403_BT10_5M_D1D2	1/2	500mA	36 seconds	single start, long close	10mA	no	no	4K
	IP5403_BT10_2M	4	200mA	36 seconds	single start, long close	10mA	no	no	4K
	IP5403_BT10_2M_D1D2	1/2	200mA	36 seconds	single start, long close	10mA	no	no	4K

6. Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Input Voltage Range	V_{IN}	-0.3 ~ 15	V
Junction Temperature Range	T_J	-40 ~ 150	°C
Storage Temperature Range	T_{stg}	-60 ~ 150	°C
Thermal Resistance (Junction to Ambient)	θ_{JA}	50	°C/W
ESD (Human Body Model)	ESD	4	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.

7. Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input Voltage	V_{IN}, V_{BUS}	4.5	5	6.0	V
Operating Temperature	T_A	0	--	70	°C

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

8. Electrical Characteristics

Unless otherwise specified, TA=25°C, L=1uH

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Charging System						
Input Voltage	V _{IN}	V _{BAT} =3.7V	4.5	5	6.0	V
Input Over Voltage	V _{INOV}		10	12	15	V
VIN activation voltage	V _{INOK}		3.0	3.2	3.4	V
Input Under Voltage	V _{INUV}		4.0	4.2	4.4	V
Constant Charge Voltage	CV _{4.2V}	4.2V battery	4.15	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
Charge Stop Current	I _{vinstop}	V _{IN} =5V	10	15	20	mA
Charge Current	I _{VIN}	V _{IN} =5V, V _{BAT} =3.7V, Set the charge current=300mA	260	300	340	mA
Trickle Charge Current	I _{TRKL}	V _{IN} =5v, BAT=2.7v	20	25	30	mA
Trickle Charge Stop Voltage	V _{TRKL}		2.9	3	3.1	V
Recharge Voltage Threshold	V _{RCH}		4.07	4.1	4.13	V
Charge Cut-Off Time	T _{END}		20	24	28	Hours
Boost System						
BatteryOperation Voltage	V _{BAT}		3.0	3.7	4.4	V
Low Power Shutdown Voltage	V _{BATLOW}	I _{OUT} =200mA	2.9	2.95	3.0	V
Switching battery input current	I _{BAT}	V _{BAT} =3.7V,V _{OUT} =5.0V, fs=1.5MHz(without LED indicator, V _{OUT} without load)		4	6	mA
DC Output Voltage	V _{OUT}	V _{BAT} =3.7V @0A	5.0	5.05	5.15	V
		V _{BAT} =3.7V @200mA	4.75	5.00	5.15	V
Output Voltage Ripple	ΔV _{OUT}	V _{BAT} =3.0V~4.4V	50	100	150	mV
Boost Output Current	I _{vout}	V _{BAT} =3.0V~4.4V	0		300	mA
Boost Overcurrent Shut	I _{shut}	V _{BAT} =3.0V~4.4V	0.7	0.8	0.9	A

Down Threshold						
Load Overcurrent Detect Time	T_{UVD}	Duration of output voltage under 4.2V		30		ms
Control System						
Switch Frequency	fs	Discharge switch frequency	1.3	1.5	1.6	MHz
PMOS On Resistance	r_{DSON}			450		mΩ
NMOS On Resistance				330		mΩ
Vcc Voltage	VCC	VCC = VBAT. (When no VBAT is connected, only VIN supplies power and the charger is disabled, then the VCC is 3.3V)	VBAT-0.1	VBAT	VABT	V
Battery Input Standby Current	I_{STB1}	VIN=0V, VBAT=3.7V	20	27	35	uA
Battery Input Standby Current 2	I_{STB2}	VIN=0V, VBAT=3.7V, support hall switch	30	35	40	uA
IO Driving Current	I_{Gpio}		4	6	8	mA
Light Load Shut Down Detect Time	T_{loadD}	Load current less than 4mA	5	6	8	s
Light Load Shut Down Current	I_{plout}	VBAT=3.7V, The load current of both headphones must be less than I_{plout} to shut down.	3	4	5	mA
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

9. Function Description

System Diagram

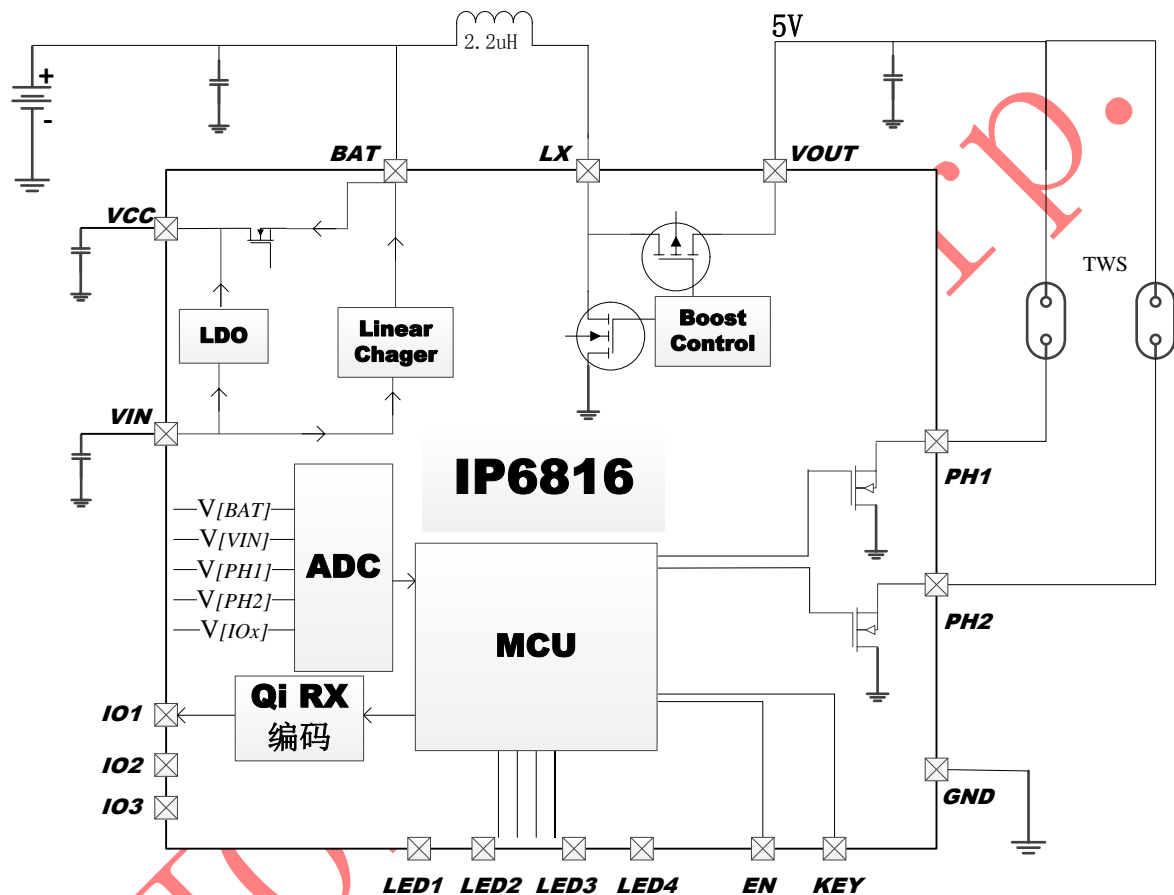


Figure 3 IP6816 Internal System Diagram

Boost

IP6816 integrates a boost dc-dc converter with 5V/300mA output, 1.5MHz switching frequency. 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.

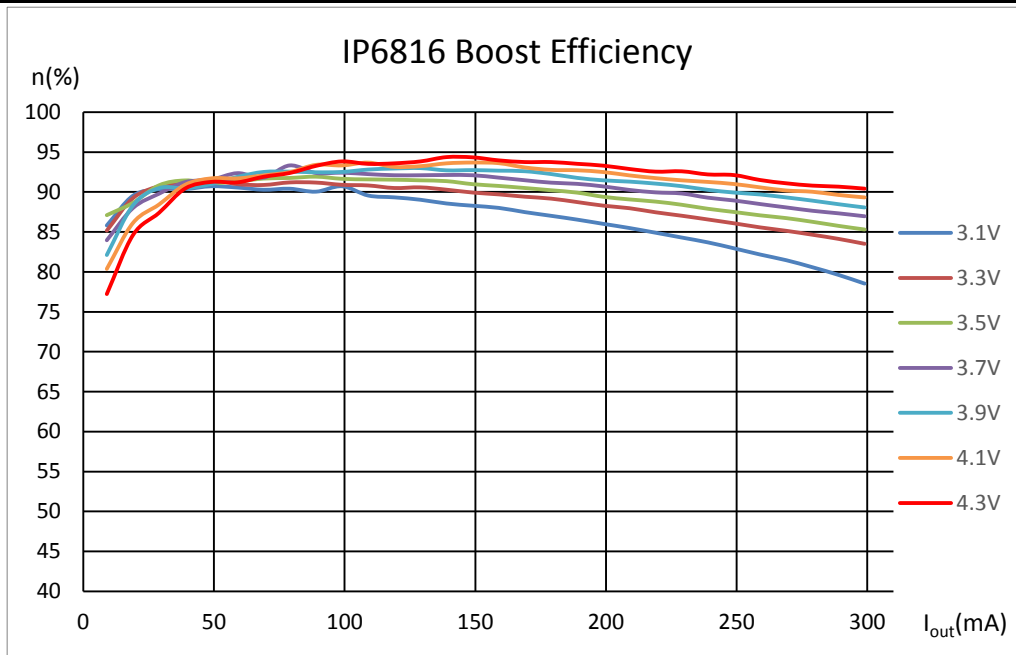


Figure 4 IP6816 Boost Efficiency Curve

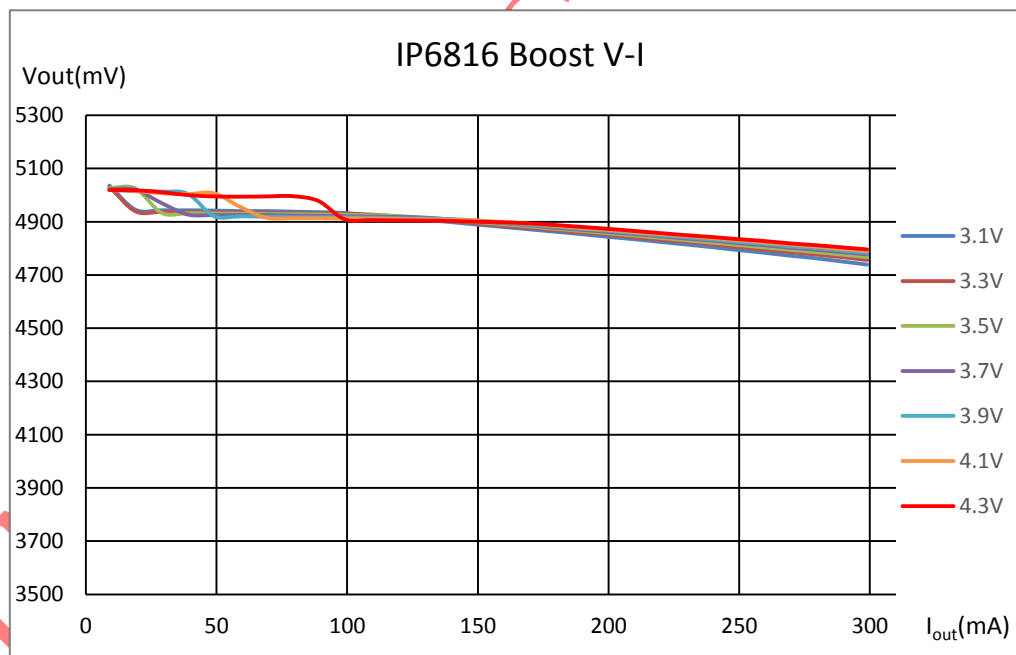


Figure 5 IP6816 Boost Output V-I Curve

Charge

IP6816 integrates a linear lithium battery charger. When the battery voltage is less than 3V, precharge with 0.1 CC; 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. When the charging is accomplished, once the battery voltage falls under 4.1V, battery charging stage will be restarted.

IP6816 supports max 500mA charging, with change of the IC temperature and input voltage, IP6816 can

intelligently adjust charging current.

IP6816 can select the constant current charging current of the battery by connecting different resistors on the IO2 pin..

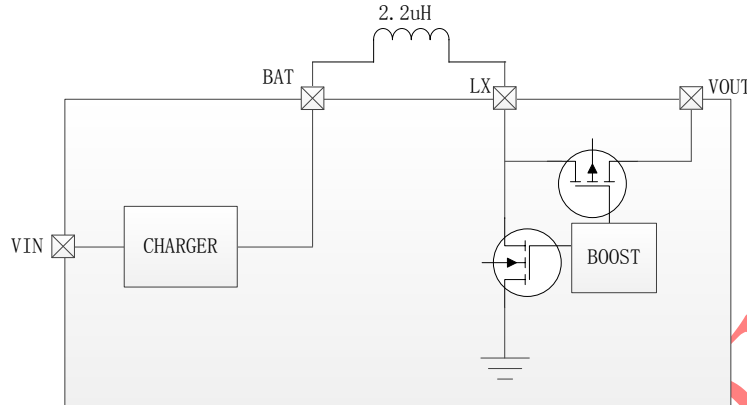


Figure6 IP6816 Power Path Diagram

Qi wireless power receive charging

IP6816 supports the Qi protocol wireless charging reception function. The resonant capacitor of the wireless receiving function needs to be adjusted according to the coil inductance. Please contact INJOINIC Support Department directly.

When the device is wired charging and put on the wireless charging TX, the IP6816 preferentially uses wired charging, and the wireless charging receiving function is actively turned off.

Coulombmeter and battery level display

IP6816 has a built-in power algorithm, which can accurately display the remaining battery power according to the cell capacity.

IP6816 can support 1/2/3/4 LED battery indicator, and the system can automatically identify several LED modes.

LED light display mode

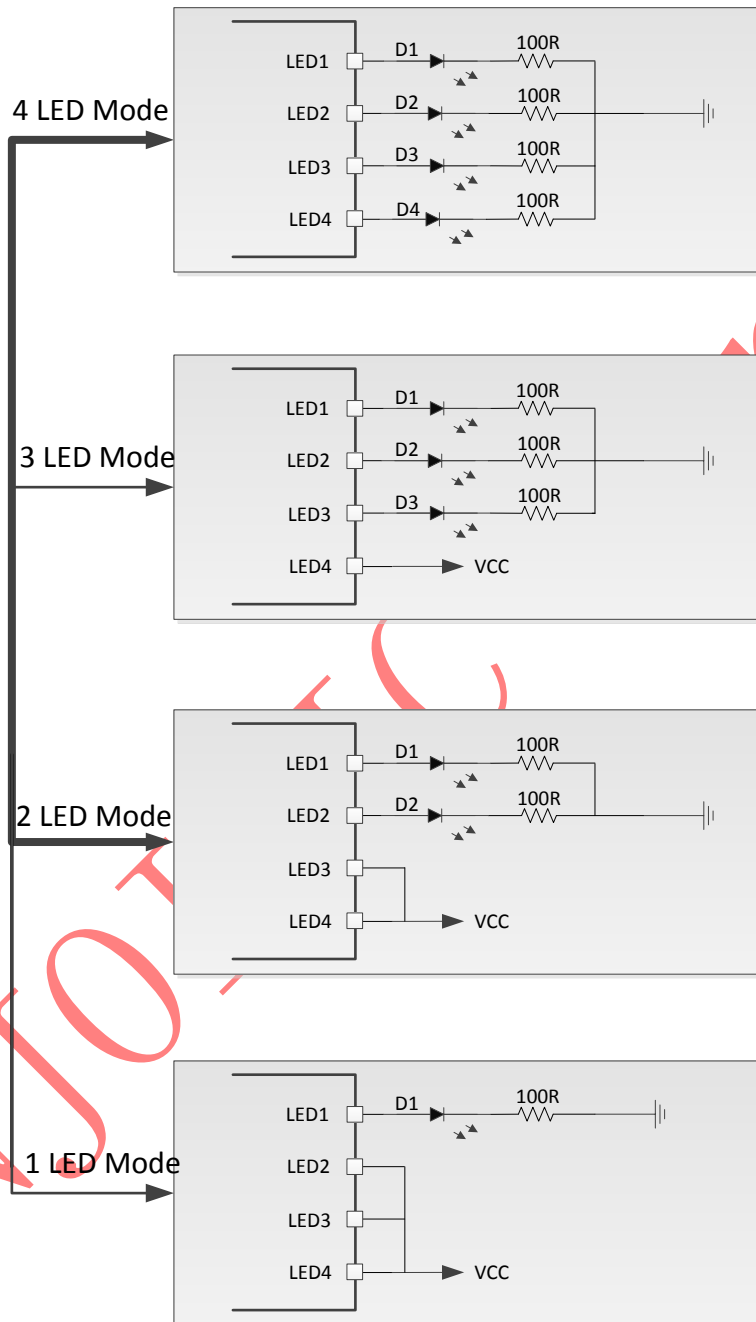


Figure 7 LED Mode Selection Circuit

■ 4 LED Mode

Discharge

Battery capacity(c)(%)	LED1	LED2	LED3	LED4
C≥75%	on	on	on	on

$50\% \leq C < 75\%$	on	on	on	off
$25\% \leq C < 50\%$	on	on	off	off
$3\% \leq C < 25\%$	on	off	off	off
$0\% < C < 3\%$	1Hz blink	off	off	off

Charge

Battery capacity(c)(%)	LED1	LED2	LED3	LED4
full	on	on	on	on
$75\% \leq C$	on	on	on	0.5Hz blink
$50\% \leq C < 75\%$	on	on	0.5Hz blink	off
$25\% \leq C < 50\%$	on	0.5Hz blink	off	off
$C < 25\%$	0.5Hz blink	off	off	off

■ 3 LED Mode

Discharge

Battery capacity(c)(%)	LED1	LED2	LED3
$C \geq 66\%$	on	on	on
$33\% \leq C < 66\%$	on	on	off
$3\% \leq C < 33\%$	on	off	off
$0\% < C < 3\%$	1Hz blink	off	off

Charge

Battery capacity(c)(%)	LED1	LED2	LED3
$75\% \leq C$	on	on	on
$66\% \leq C < 100\%$	on	on	0.5Hz blink
$33\% \leq C < 66\%$	on	0.5Hz blink	off
$C < 33\%$	0.5Hz blink	off	off

■ 2 LED Mode

	state	LED1	LED2
charge	charging	0.5Hz 闪烁	off
	full	on	off
discharge	dischargeing	off	on
	low	off	1Hz blink

■ 1 LED Mode

	state	LED1
charge	charging	0.5Hz blink
	full	on
discharge	dischargeing	on
	low	1Hz blink

NTC

IP6816 support NTC function used for battery temperature detection. NTC pin outputs 20uA current then detects the voltage on NTC resistance to determine the present battery temperature.

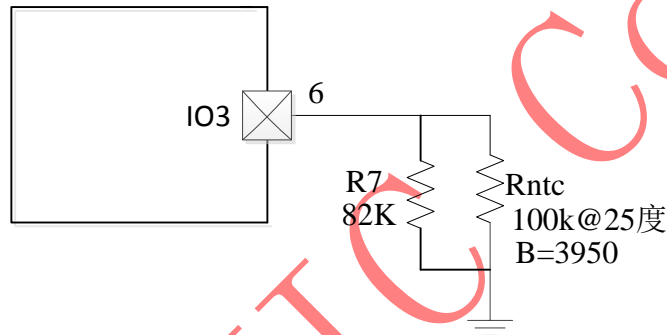


Figure8 NTC circuit

Under charging state:

Voltage on NTC resistance is higher than 1.3V meaning the battery temperature is under 0 centigrade, then stop charging the battery;

Voltage on NTC resistance is lower than 0.5V meaning the battery temperature is above 50 centigrade, then stop charging the battery;

Under discharging state:

Voltage on NTC resistance is higher than 1.47V meaning the battery temperature is under -15 centigrade, stop discharging;

Voltage on NTC resistance is lower than 0.44V meaning the battery temperature is above 55 centigrade, stop discharging.

If NTC function is not required in the scheme, the IO3 pin shall be connected 51K to GND. IO3 pin shall not float, otherwise abnormal charging and discharging may be caused.

plug-in/plug-out detection

Once detecting the insertion of the earphone, the IP6816 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 IP6816 supports light-load auto standby function. When the earphone's load current on PH1 and PH2 are less than 4mA for 16 seconds, IP6816 will automatically enter standby mode. In the standby mode, the VOUT pin voltage has three configurations: 5V, VBAT, and 2.4V. The standard standby VOUT output voltage is 2.4V, and other

specifications need to be customized separately.

When the earphones are charged end, the IP6816 will enter standby mode and the VOUT output will change to 2.4V. In this case, in order to make the earphones also enter power-saved mode, You need to adjust the resistance R8/R9 on PH1/PH2. Taking PH1 as an example, the adjustment method is as follows:

1. R8 default resistance is 100K
2. If IP6816 can enters standby mode , but the earphone cannot enter the standby mode, then gradually reduce the R8.
3. If IP6816 can enters standby , but it can not be waked up by the earphone's plug-in, then gradually increase the R8.
4. Repeat steps 2/3 until you find a suitable resistor R8, which makes IP6816 can enter standby mode, and the earphone can enter stanby mode, and IP6816 can be waked up by the plug-in of earphone.

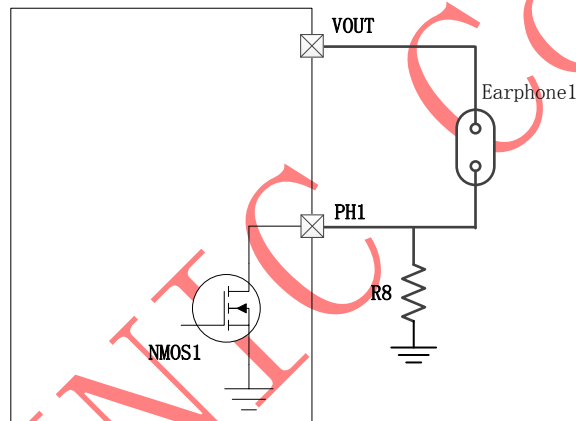
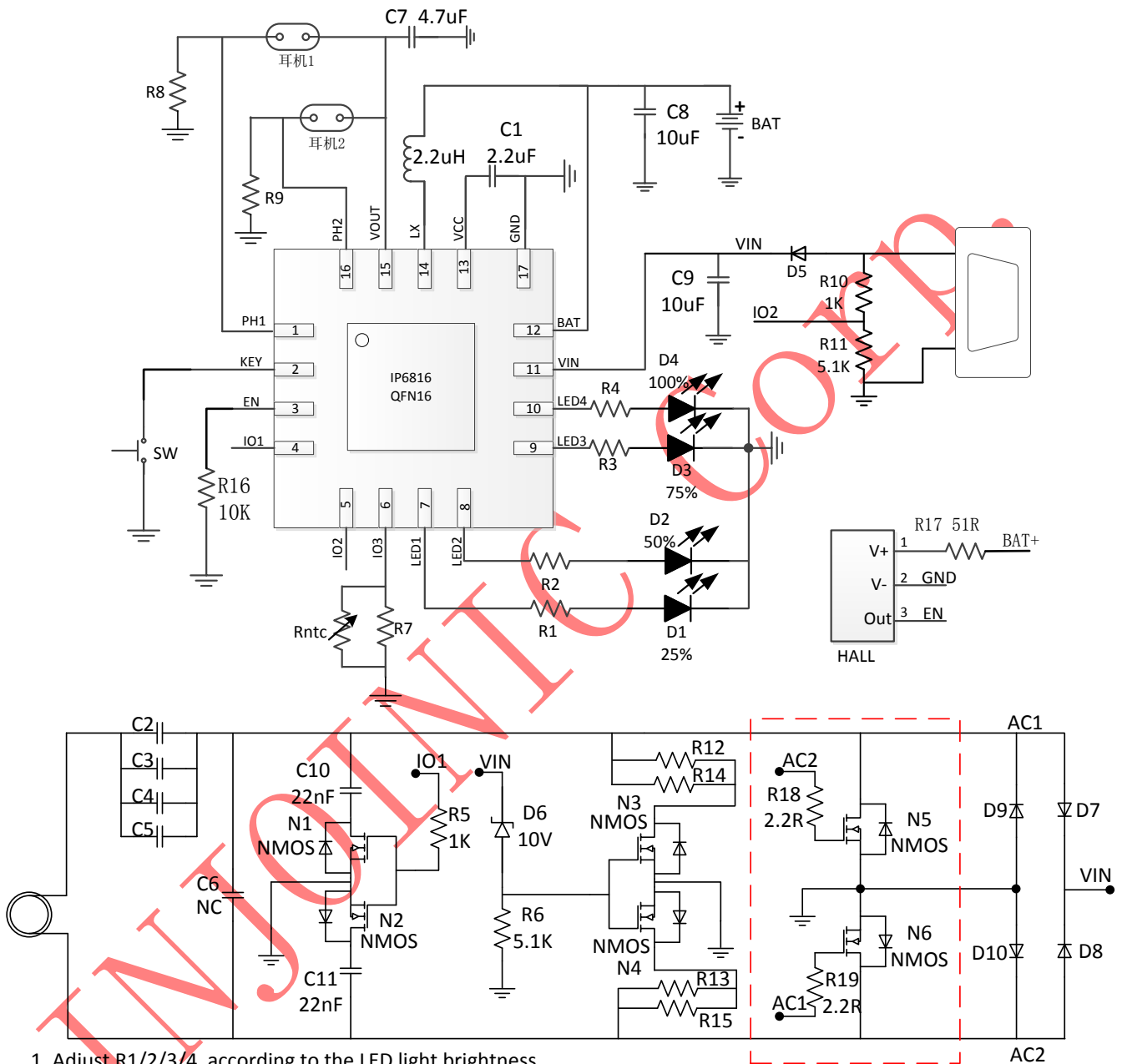


Figure9 IP6816 Earphone Standby Resistance Adjustment Diagram

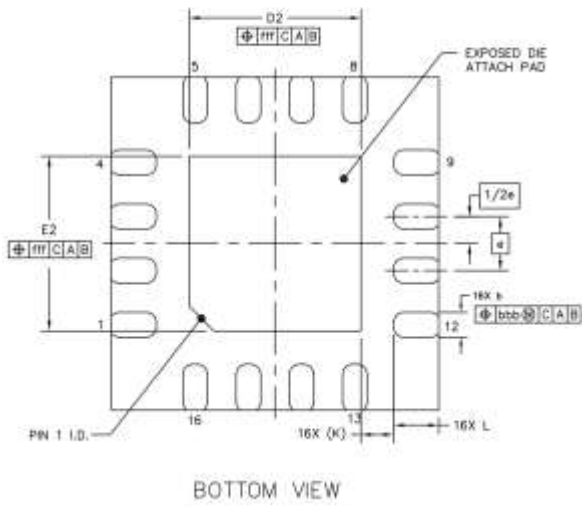
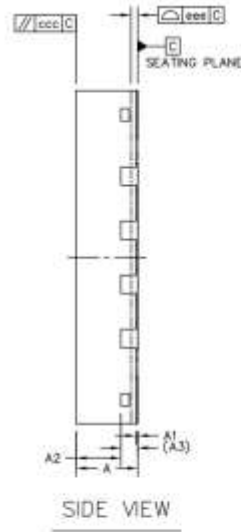
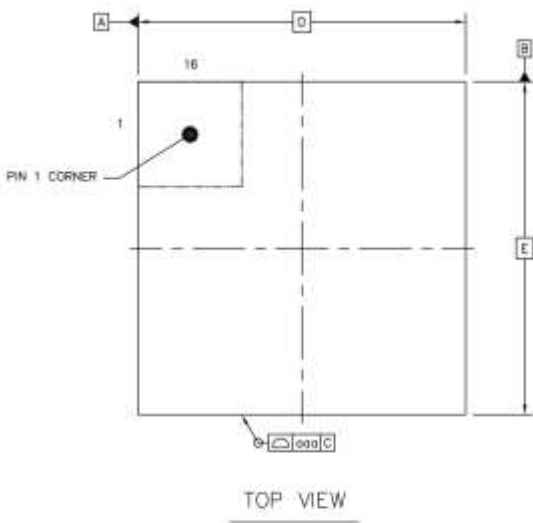
10. Typical Application Diagram



1. Adjust R1/2/3/4 according to the LED light brightness.
2. When NTC function is supported, R7=82K , Rntc=100K@25°C, B=3950.
When NTC function is not supported, R7=51K , Rntc is floating.
3. Please adjust R8/R9 according to different Bluetooth earphone solutions
4. N1/N2/N3/N4 are withstand voltage 20V NMOS, transient current maximum 5A, constant current 1A
5. D5/D7/D8/D9/D10 are Schottky diode, constant current 1A
6. D6 is 10V Zener Diode
7. C2/C3/C4/C5 value should be according to different coil inductance values
8. R12/R14/R13/R15 value should be according to different coil inductance values
9. If Hall element is supported, R16 requires NC
10. The D9/D10 can be replaced with NMOS (N5/N6) in the red dashed box to improve wireless charging efficiency and reduce heat

Figure10 IP6816 Typical Application Diagram

11. Package





	SYMBOL	MIN	NOM	MAX
TOTAL THICKNESS	A	0.7	0.75	0.8
STAND OFF	A1	0	0.02	0.05
MOLD THICKNESS	A2	---	0.55	---
L/F THICKNESS	A3	0.203 REF		
LEAD WIDTH	b	0.25	0.3	0.35
BODY SIZE	X	4 BSC		
	Y	4 BSC		
LEAD PITCH	e	0.65 BSC		
EP SIZE	X	D2	2	2.1
	Y	E2	2	2.1
LEAD LENGTH	L	0.45	0.55	0.65
LEAD TIP TO EXPOSED PAD EDGE	K	0.4 REF		
PACKAGE EDGE TOLERANCE	ooo	0.1		
MOLD FLATNESS	ccc	0.1		
COPLANARITY	eee	0.08		
LEAD OFFSET	bbb	0.1		
EXPOSED PAD OFFSET	fff	0.1		

IN

12. Mark description



Note:

- 1、  ——Injoinic Logo
- 2、 IP6816 ——Part Number
- 3、 LLLLLLLL——Manufacture number
- 4、  ——Pin1 location

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