

TWS Bluetooth Earphone Charging Box SOC integrated with 500mA 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 500mA 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 4/2/1 LED battery indicator
- **Low-power dissipation**
 - ◇ Automatically detect earphone plugged-in/plugged-out/charger-end, Automatically enter standby mode
 - ◇ Standby power consumption up to 10uA 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 12V(transient voltage)
- ◇ ESD 2KV

2. Applications

- TWS Bluetooth Earphone Charging Box

3. Description

IP5413T 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.

IP5413T 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 IP5413T provides rated 200mA output current with conversion efficiency up to 95%, can support low-cost inductors and capacitors.

IP5413T's linear charger supplies max 500mA charging current. With the change of IC temperature and input voltage, IP5413T can automatically adjust the charging current.

IP5413T 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 10uA.

IP5413T can support 4/2/1 LED battery indicator.

IP5413T is packaged with SOP8.

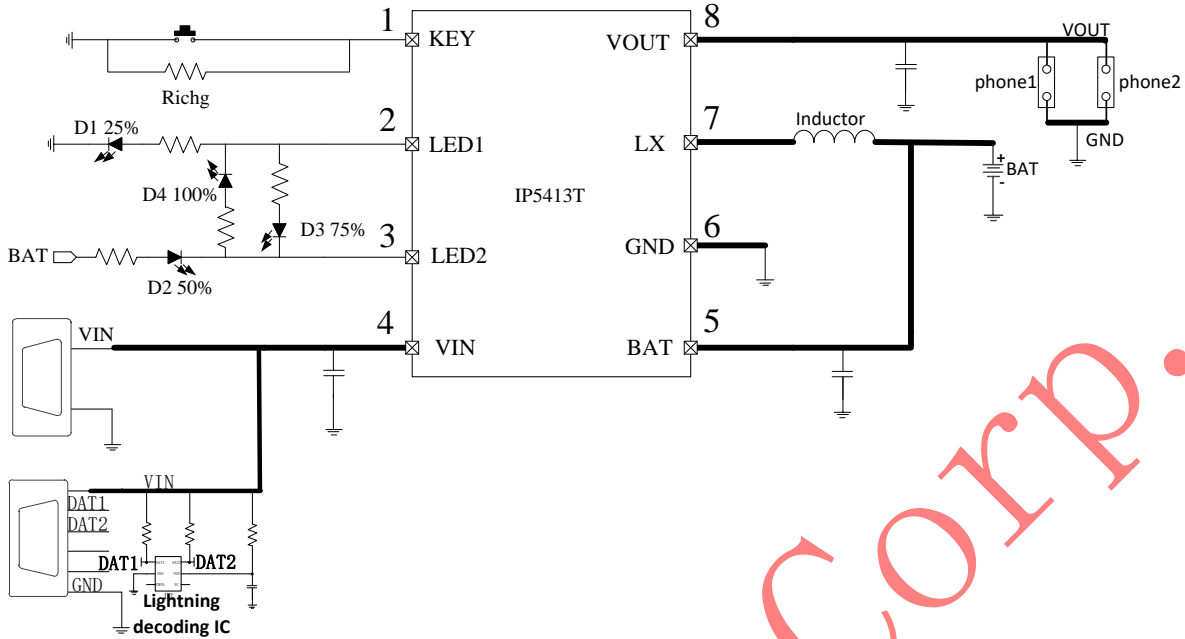


Figure1 IP5413T Simplified Application Diagram

4. Pin Definition

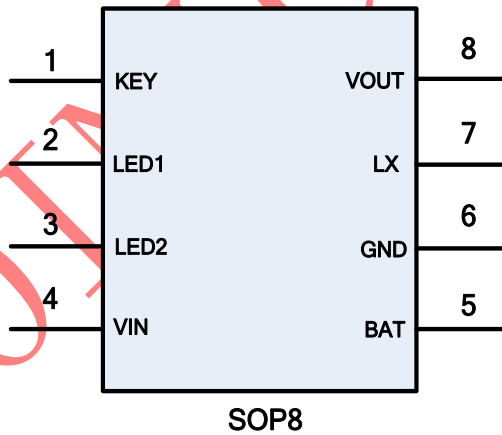


Figure2 IP5413T Pin Assignments

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

5. IP5413T IC Products List

IC part No.	Charging Current	Standby VOUT voltage	LED Mode	Key Mode	Light load shut down/light off Time
IP5413T_BT_2D	200mA	2.4V	2	Single start Single close	8S
IP5413T_BT_1D	200mA	2.4V	1	Single start Single close	8S
IP5413T_BT_4D	200mA	2.4V	4	Single start Single close	8S
IP5413T_BT_2D_ISET	Richg choose	2.4V	2	Single start Single close	8S
IP5413T_BT_1D_ISET	Richg choose	2.4V	1	Single start Single close	8S
IP5413T_BT_4D_ISET	Richg choose	2.4V	4	Single start Single close	8S
IP5413T_CK_2D	200mA	5V	2	Single start	8S
IP5413T_CK_1D	200mA	5V	1	Single start	8S
IP5413T_CK_4D	200mA	5V	4	Single start	8S
IP5413T_CK_2D_ISET	Richg choose	5V	2	Single start	8S
IP5413T_CK_1D_ISET	Richg choose	5V	1	Single start	8S

6. 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

7. Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Input Voltage Range	V_{IN}	-0.3 ~ 12	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.

8. Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input Voltage	V_{IN}, V_{BUS}	4.5	5	5.8	V
Operating Temperature	T_A	0	--	70	°C

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

9. 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}	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}		5.5	5.8	6.0	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	$I_{vinstop}$	VIN=5V		30	40	mA
Charge Current	I_{VIN}	VIN=5V, VBAT=3.7V, Set the charge current=300mA	275	300	325	mA
Trickle Charge Current	I_{TRKL}	VIN=5V, BAT=2.7v, Iset=300mA		30		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	3.0	3.1	3.2	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	300	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 of both headphones must be less than Iplout to shut down.		5		mA
Load Over current Detect Time	T_{UVD}	Duration of output voltage under 4.2V		30		ms
Load short circuit Detect		Duration of output voltage under		20		us

Time		Battery voltage				
Control System						
Switch Frequency	fs	Discharge switch frequency	0.9	1.1	1.3	MHz
PMOS On Resistance	r _{DSON}			450		mΩ
NMOS On Resistance				550		mΩ
Battery Input Standby Current 1	I _{STB1}	VIN=0V,VBAT=3.7V,VOUT=2.4V/0V		11		uA
Battery Input Standby Current 2	I _{STB2}	VIN=0V,VBAT=3.7V,VOUT=5.0V		12		uA
LED Driving Current	I _{LED}		4	6	8	mA
Light Load Shut Down Detect Time	T _{loadD}	Load current less than I _{PLOUT}	6	8	10	s
Short Press On Key Wake Up Time	T _{OnDebounce}		100		500	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

10. Function Description

System Diagram

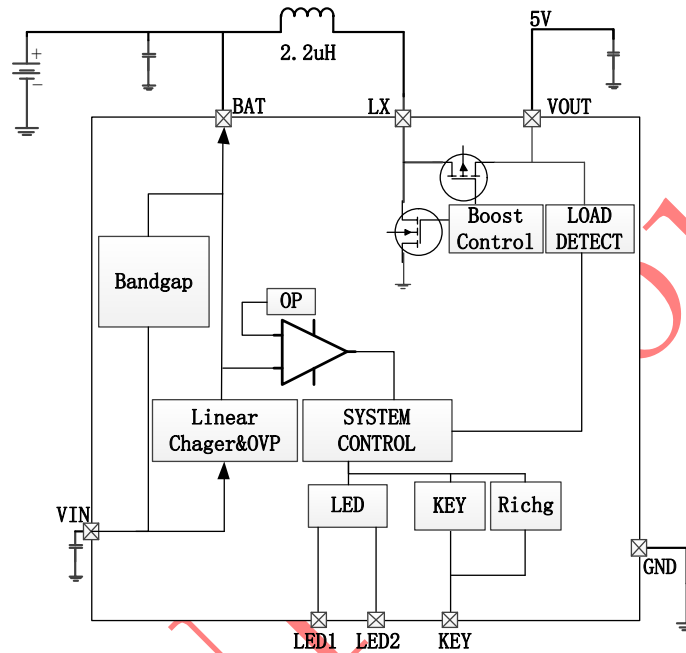


Figure3 IP5413T Internal System Diagram

Boost

IP5413T 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, IP5413T boost system can intelligently adjust output current, ensuring the IC temperature is below the set temperature.

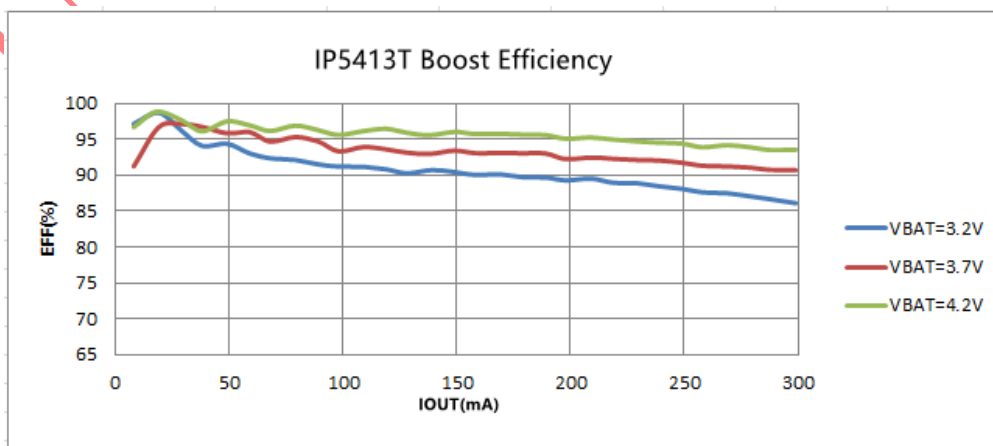


Figure4 IP5413T Boost Efficiency Curve

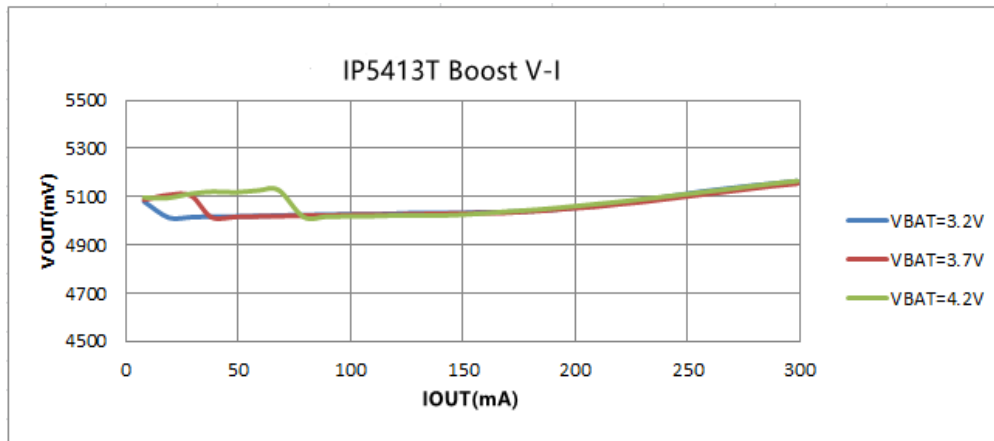


Figure5 IP5413T Boost Output V-I Curve

Charge

IP5413T integrates a linear lithium battery charger. When the battery voltage is less than 3V, precharge with $20\text{mA} + I_{\text{set}} * 5\%$. 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.

IP5413T supports max 500mA linear charging, According to the IC temperature and input voltage, IP5413T can intelligently adjust charging current.

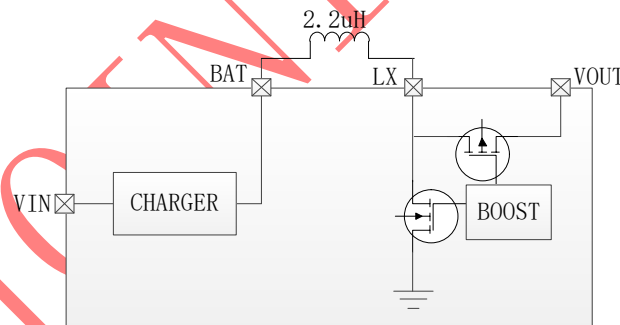


Figure6 IP5413T Power Path Diagram

Battery level display

IP5413T has a built-in power algorithm, which can accurately display the remaining battery power according to the cell capacity.

IP5413T can support 1/2/4 LED battery indicator. And the 1/2/4 LED are not automatic identification, all need to be customized separately.

In the model name: "-1D" means 1 LED display application; "-2D" means 2 LED display application; "-4D" means 4 LED display application. If there is no "-1D", "-2D", "-4D" words in the model name, the default support 2 LED display application.

LED light display mode

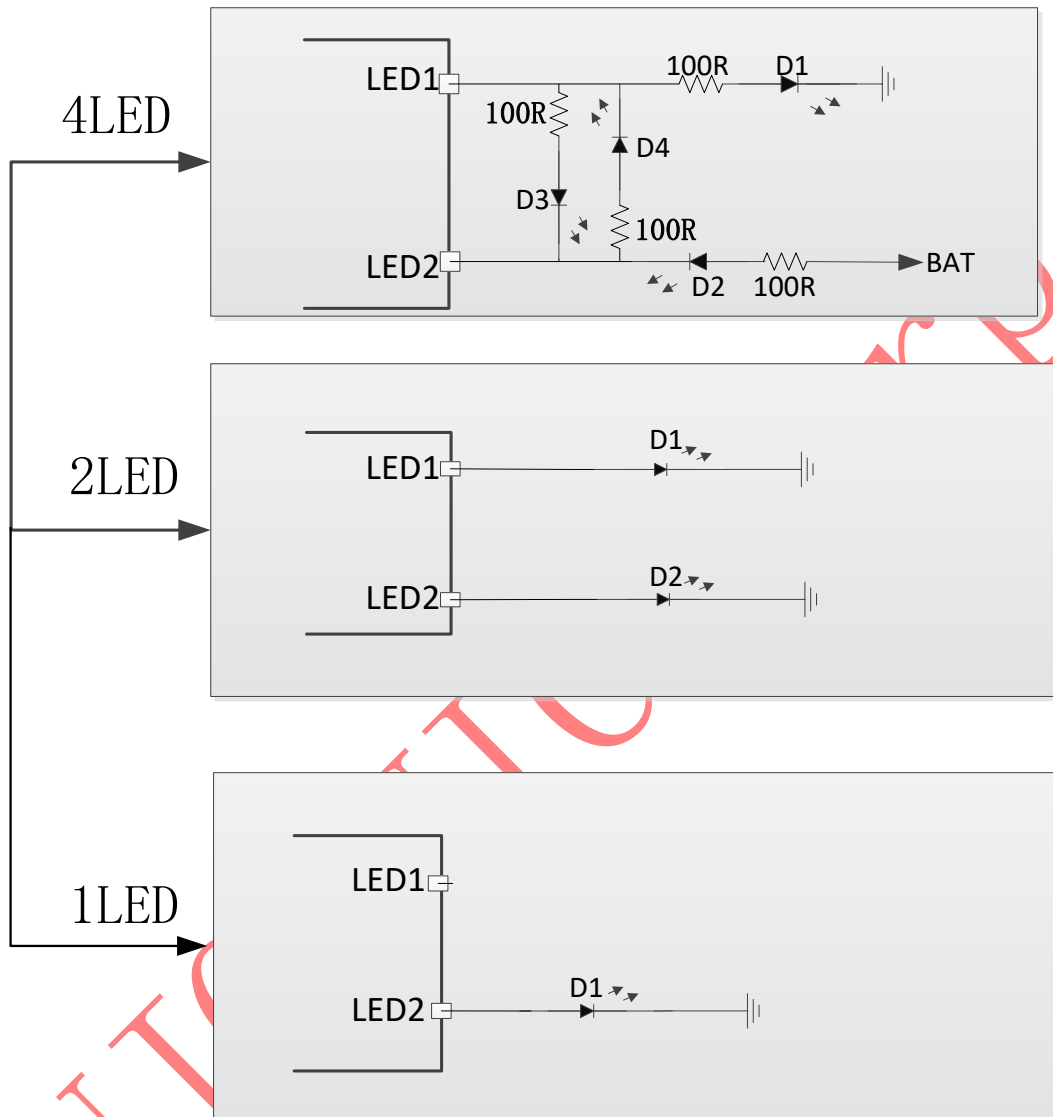


Figure7 LED Mode Selecion Circuit

■ IP5413T 4 LED Mode

Discharge

Battery capacity(c)(%)	D1	D2	D3	D4
$C \geq 75\%$	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)(%)	D1	D2	D3	D4
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

■ IP5413T 2 LED Mode

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

■ IP5413T 1 LED Mode

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

KEY Function

IP5413T support single start, single close

Short press (pressed time in range of 60ms~2s): turn on the battery level display LED and BOOST output.

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

IP5413T can select the charging current by connecting different resistors on the KEY pin.

Only the “-ISET” model supports this function.

The recommended configuration of I_{CHG_set} is as follows:

Recommended resistance value/ Ω	I_{chg}/mA
22k	230
47k	330
68k	430

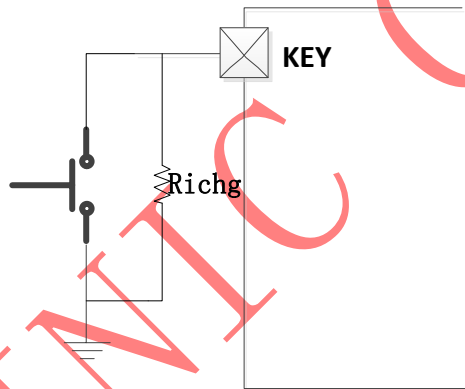


Figure8 Key circuit

plug-in/plug-out detection

Once detecting the insertion of the earphone, the IP5413T 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 IP5413T supports light-load auto standby function. When the earphone's load current on VOUT are less than 4mA for 8 seconds, IP5413T will automatically enter standby mode.

When the earphones are charged end, IP5413_BT series will enter standby mode and the VOUT output will change to 2.4V.

When the earphones are charged end, IP5413_CK series will enter standby mode and the VOUT output will change to 5V.

When the earphones are charged end, IP5413_NAT series will enter standby mode and the VOUT output will change to 0V.

11. Typical Application Diagram

Total solution of IP5413T charging Box is merely realized by passive devices of inductors, capacitors and resistors.

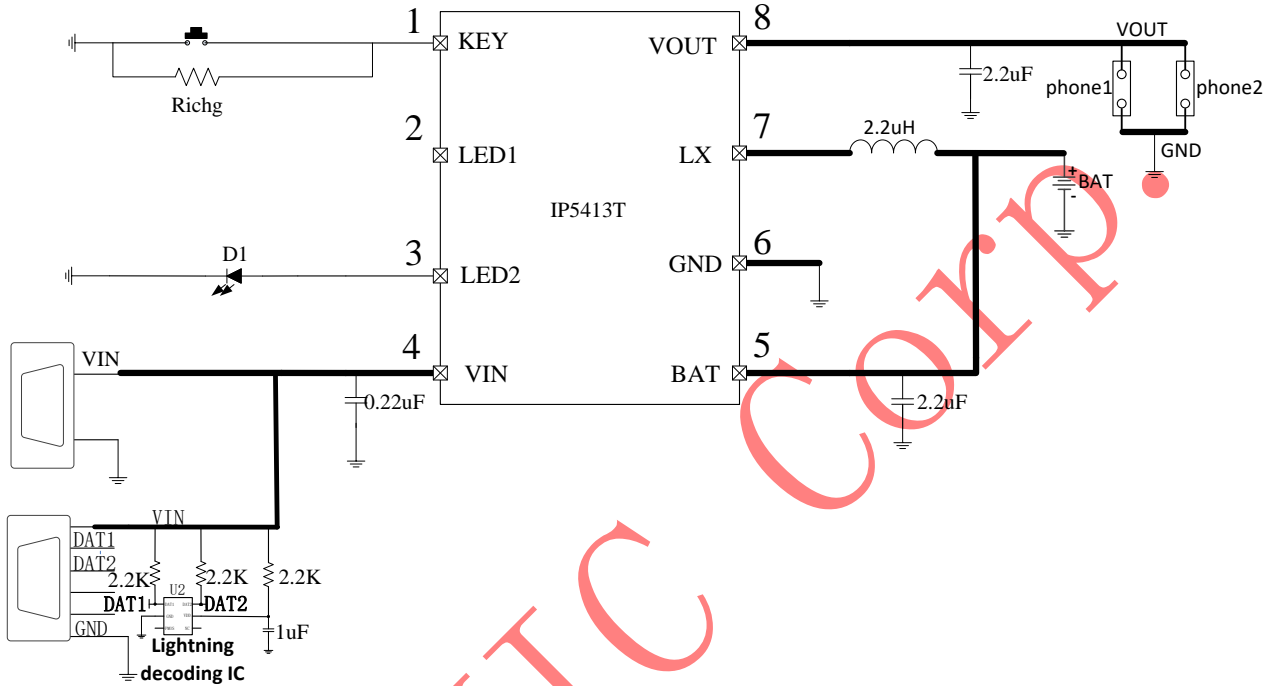


Figure9 1 LED Mode Typical Application Diagram

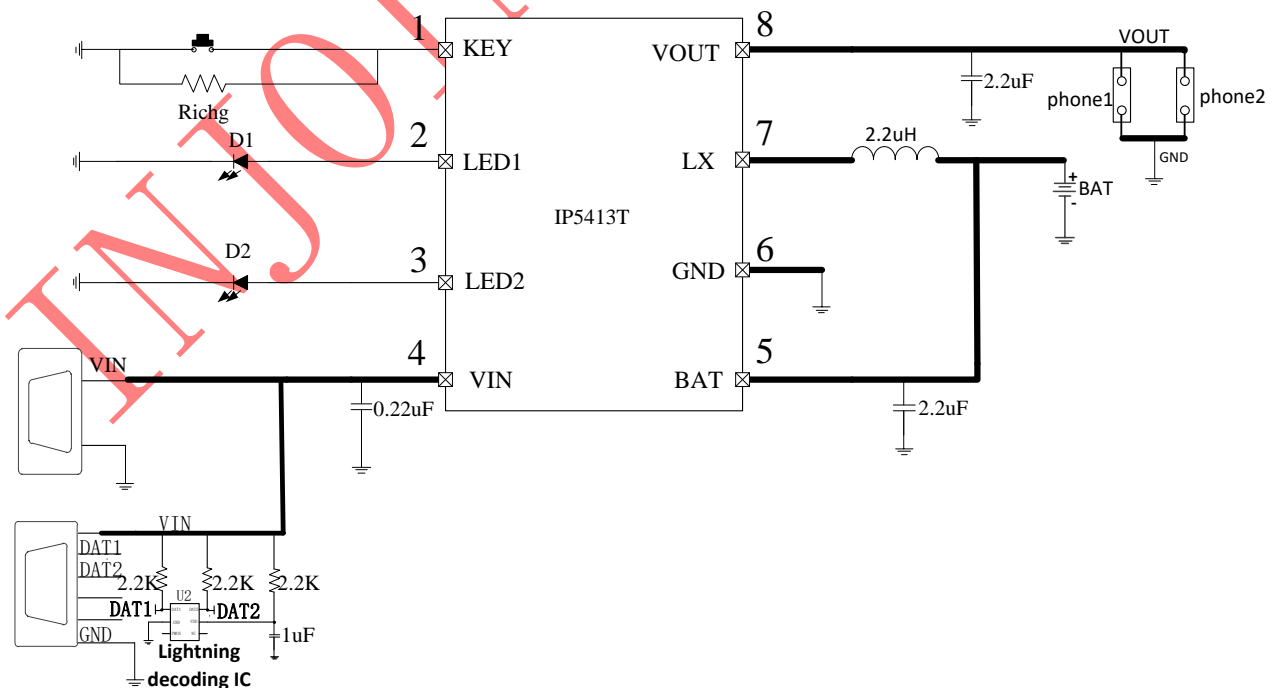


Figure10 2LED Mode Typical Application Diagram

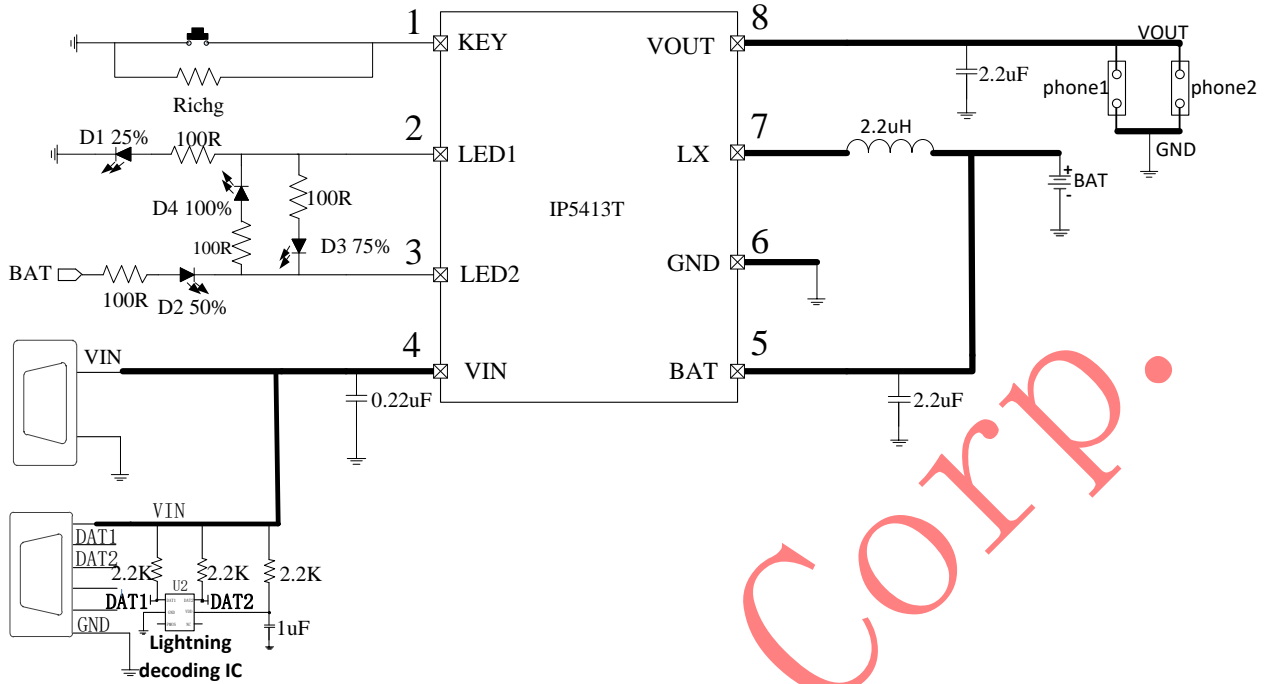
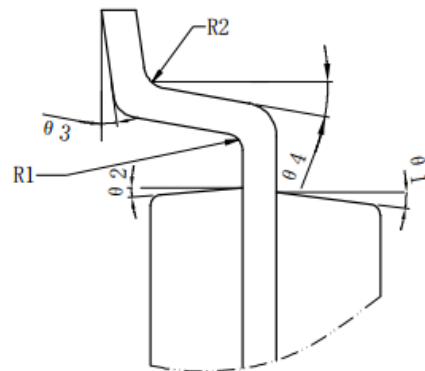
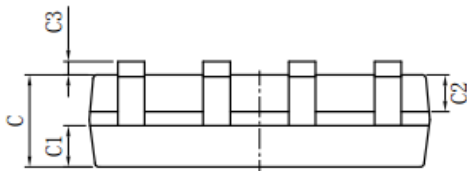
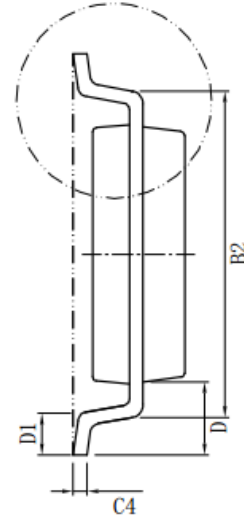
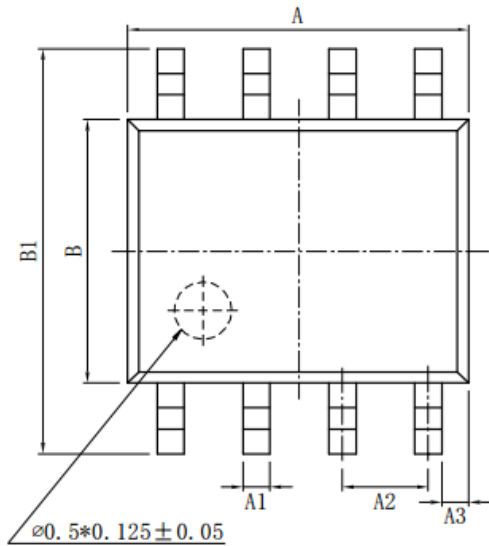


Figure11 4LED Mode Typical Application Diagram

12.Package



mark	size	min (mm)	max (mm)	mark	size	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		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°	



13.Mark description



Note:

- 1、  --Injoinic Logo
- 2、 IP5413T --Part Number
- 3、 XXXXXXXX --Manufacture number
- 4、  --PIN1 location

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