

## TWS Bluetooth Earphone Charging Box SOC integrated with MCU

### 1. Features

- **Discharge**
  - ◇ 300mA Synchronous Boost Conversion
  - ◇ Boost efficiency up to 93%
  - ◇ 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
- **Battery indicators**
  - ◇ Built-in 10bits ADC , accurate calculation of battery capacity
  - ◇ Supports 4/3/2/1 LED battery indicator
  - ◇ Supports 188 digital tube battery indicator
- **Low-power dissipation**
  - ◇ Automatically detect earphone plugged-in/charger-end, Automatically enter standby mode
  - ◇ Support detection of dual earphone plug-in independtly
  - ◇ 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 protection 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: SOP16**

### 2. Applications

- TWS Bluetooth Earphone Charging Box
- Lithium Battery Portable Device

### 3. Description

IP5513 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.

IP5513 is highly integrated with abundant functions, which makes the total solution with minimized-size and low-cost BOM.

The synchronous 5V-boost system of IP5513 provides rated 300mA output current with conversion efficiency up to 93%. DC-DC converter operates at 1.5MHz frequency, can support low-cost inductors and capacitors.

IP5513's linear charger supplies max 500mA charging current. With the change of IC temperature and input voltage, IP5513 can automatically adjust the charging current.

IP5513 can detects the TWS earphone plug-in 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, charge-end current detection accuracy is up to 1mA.

IP5513 can support 1/2/3/4 LED battery indicator or 188 digital tube battery indicator. The built-in 10bits ADC can accurately calculate the Charging Box's battery capacity.

IP5513 is packaged with SOP16.

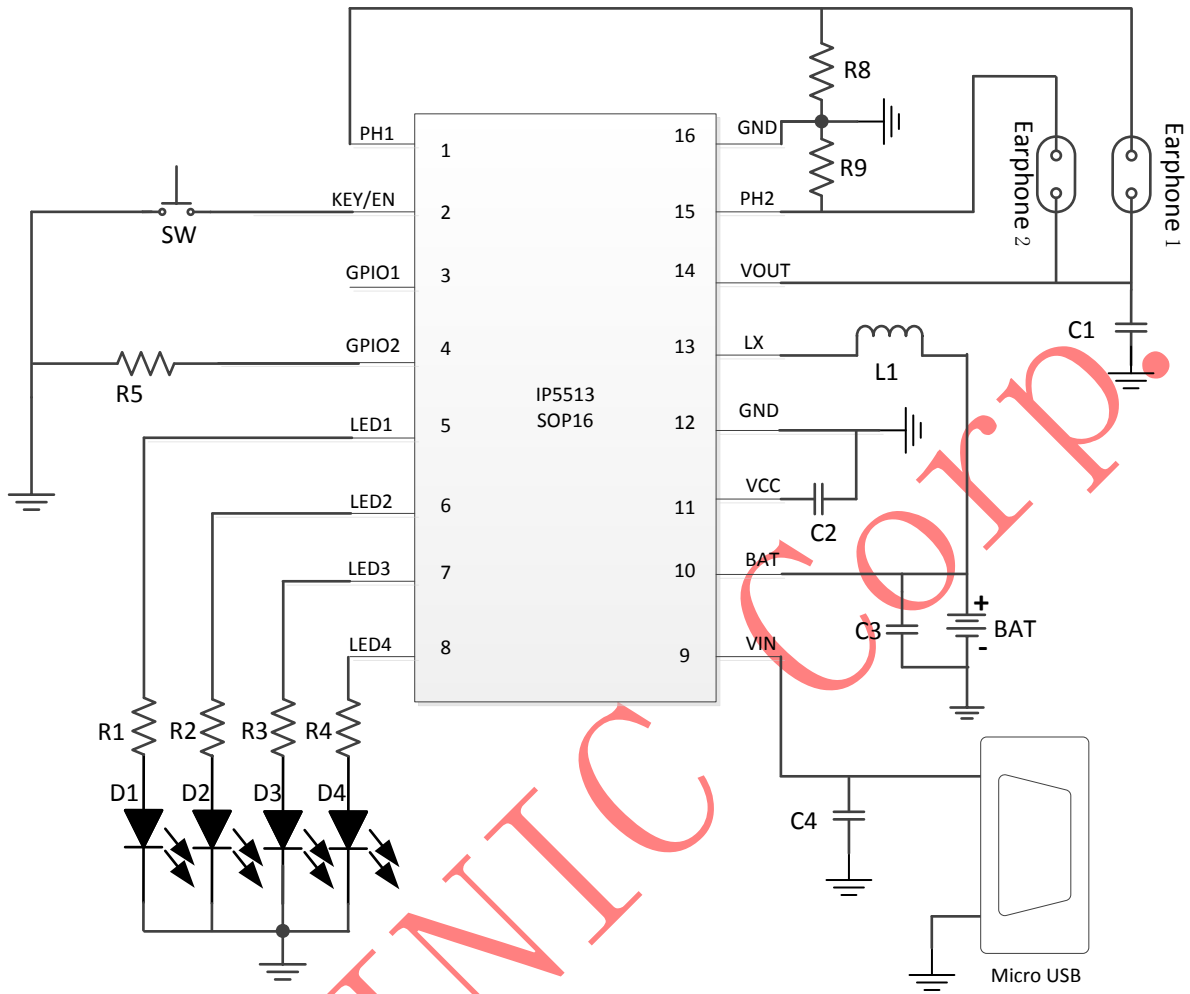


Figure1 IP5513 Simplified Application Diagram

## 4. Pin Definition

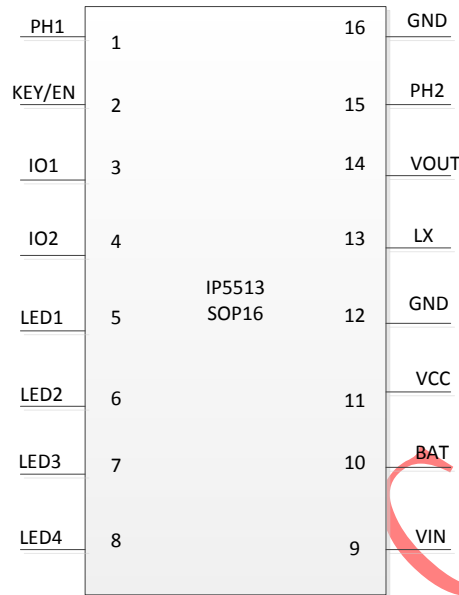


Figure2 IP5513 Pin Assignments

Pin Num	Pin Name	Description
1	PH1	Earphone 1 negative
2	KEY/EN	Key/Hall
3	GPIO1	General IO
4	GPIO2	General IO
5	LED1	LED driver pin1
6	LED2	LED driver pin2
7	LED3	LED driver pin3
8	LED4	LED driver pin4
9	VIN	5V input pin
10	BAT	Battery voltage positive pin
12	VCC	LDO output pin, connect to 2.2uF inductor
12	GND	Ground
13	LX	DCDC switch node
14	VOUT	Boost 5V output
15	PH2	Earphone 2 negative
16	GND	Ground

## IP5513 IC Products List

IC Part No.	LED Mode/188 Mode	Light load shutdown/light off Time	Key Mode	Charging Current	Standby VOUT voltage	NTC	188 Flashing Description
IP5513_BZ_LED	1/2/3/4	5S	Single start, Double close	I02 option	2.4V	NO	NO
IP5513_BZ_LED_CK	1/2/3/4	5S	Single start, Light load shutdown	I02 option	5V	NO	NO
IP5513_EN_LED	1/2/3/4	5S	KEY High level, VOUT=0V	I02 option	2.4V	NO	NO
IP5513_EN_LED_CK	1/2/3/4	5S	KEY High level, VOUT=0V	I02 option	5V	NO	NO
IP5513_BZ_LEDNTC	1/2/3/4	5S	Single start, Double close	I01 option	2.4V	I02	NO
IP5513_BZ_LEDNTC_CK	1/2/3/4	5S	Single start, Light load shutdown	I01 option	5V	I02	NO
IP5513_BZ_188	YF2252SR-5	5S	Single start, Double close	I02 option	2.4V	NO	Units and tens blink together
IP5513_BZ_188_CK	YF2252SR-5	5S	Single start, Light load shutdown	I02 option	5V	NO	Units and tens blink together
IP5513_BZ_188_GWS	YF2252SR-5	5S	Single start, Double close	I02 option	2.4V	NO	Only units blink
IP5513_BZ_188_CK_GWS	YF2252SR-5	5S	Single start, Light load shutdown	I02 option	5V	NO	Only units blink
IP5513_EN_188	YF2252SR-5	5S	KEY High level, VOUT=0V	I02 option	2.4V	NO	Units and tens blink together
IP5513_EN_188_CK	YF2252SR-5	5S	KEY High level, VOUT=0V	I02 option	5V	NO	Units and tens blink together
IP5513_EN_188_GWS	YF2252SR-5	5S	KEY High level, VOUT=0V	I02 option	2.4V	NO	Only units blink
IP5513_EN_188_CK_GWS	YF2252SR-5	5S	KEY High level, VOUT=0V	I02 option	5V	NO	Only units blink
IP5513_BZ_LR188	YFTD2259SW-5	5S	Single start, Double close	I02 option	2.4V	NO	Only units blink
IP5513_BZ_LR188_CK	YFTD2259SW-5	5S	Single start, Light load shutdown	I02 option	5V	NO	Only units blink

## 5. IP Series TWS Charging IC Products List

	IP part No.	LED Mode	Charging Current	Light-Load time	Standby VOUT voltage	Key Mode	2.2uH inductance Light-load shutdown / light off current
IP5303T	IP5303T_BT_200MA	1/2	200MA	32S	2.4V	Single start, Double close	5MA
	IP5303T_BT_500MA	1/2	500MA	32S	2.4V	Single start, Double close	5MA
	IP5303T_500MA_S_NAT	1/2	500MA	32S	0V	Single start, Single close	5MA
IP5305T	IP5305T_BT	1/2/3/4	1A	32S	2.4V	Single start, Double close	5MA
	IP5305T_BT_500MA	1/2/3/4	500MA	32S	2.4V	Single start, Double close	5MA
	IP5305T_BT_300MA	1/2/3/4	300MA	32S	2.4V	Single start, Double close	5MA
	IP5305T_BT_CK	1/2/3/4	1A	32S	5V	Single start, No key close	5MA
	IP5305T_BT_CK_500MA	1/2/3/4	500MA	32S	5V	Single start, No key close	5MA
	IP5305T_BT_CK_300MA	1/2/3/4	300MA	32S	5V	Single start, No key close	5MA
	IP5305T_BT_8S	1/2/3/4	1A	8S	2.4V	Single start, Double close	5MA
	IP5305T_BT_8S_300MA	1/2/3/4	300MA	8S	2.4V	Single start, Double close	5MA

## 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)	$\theta_{JA}$	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	$V_{IN}$	4.5	5	6.0	V
Operating Temperature	$T_A$	0	--	70	°C

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

## 8. Electrical Characteristics

Unless otherwise specified,  $T_A=25^\circ\text{C}$ ,  $L=2.2\mu\text{H}$

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
<b>Charging System</b>						
Input Voltage	$V_{IN}$	$V_{BAT}=3.7\text{V}$	4.5	5	6.0	V
Input Over Voltage	$V_{INOV}$		5.8	6	6.2	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	$I_{vin\text{stop}}$	$V_{IN}=5\text{V}$	10	20	30	mA

Charge Current	$I_{VIN}$	VIN=5V, VBAT=3.7V, Set the charge current=350mA	300	350	400	mA
Trickle Charge Current	$I_{TRKL}$	VIN=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
<b>Boost System</b>						
Battery Operation Voltage	$V_{BAT}$		3.0	3.7	4.4	V
Low Power Shutdown Voltage	$V_{BATLOW}$	IOU=200mA	2.9	2.95	3.0	V
Switching battery input current	$I_{BAT}$	VBAT=3.7V, VOUT=5.0V, fs=1.5MHz(without LED indicator, VOUT without load)		4	6	mA
DC Output Voltage	$V_{OUT}$	VBAT=3.7V @0A	5.0	5.05	5.15	V
		VBAT=3.7V @300mA	4.75	5.00	5.15	V
Output Voltage Ripple	$\Delta V_{OUT}$	VBAT=3.0V~4.4V	50	100	150	mV
Boost Output Current	$I_{vout}$	VBAT=3.0V~4.4V	0		300	mA
Boost Overcurrent Shut Down Threshold	$I_{shut}$	VBAT=3.0V~4.4V	0.7	0.8	0.9	A
Load Overcurrent Detect Time	$T_{UVD}$	Duration of output voltage under 4.2V		30		ms
<b>Control System</b>						
Switch Frequency	$f_s$	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	$I_{STB}$	VIN=0V, VBAT=3.7V, no support hall switch	20	27	35	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	$\Delta T_{OTP}$		30	40	50	°C

## 9. Function Description

### System Diagram

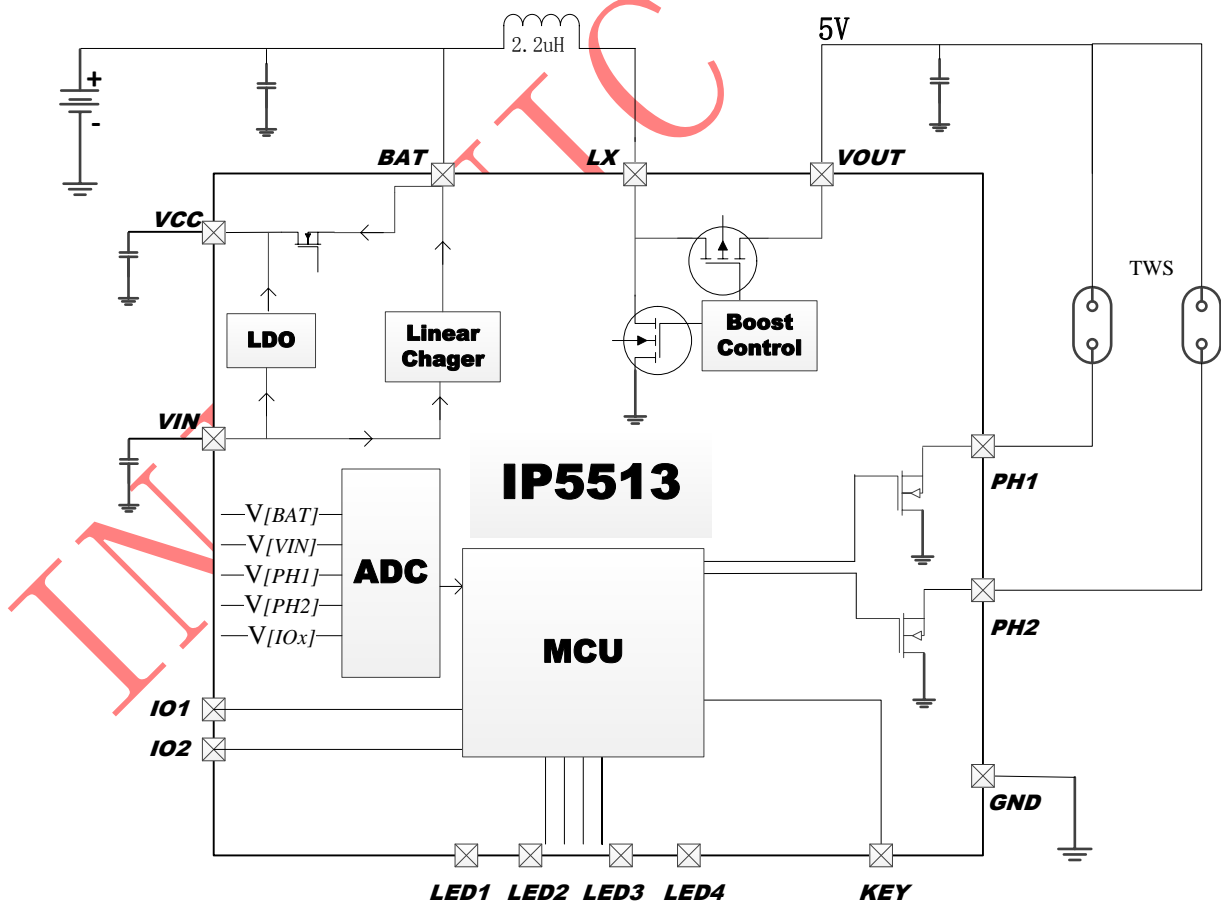


Figure3 IP5513 Internal System Diagram

## Boost

IP5513 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.

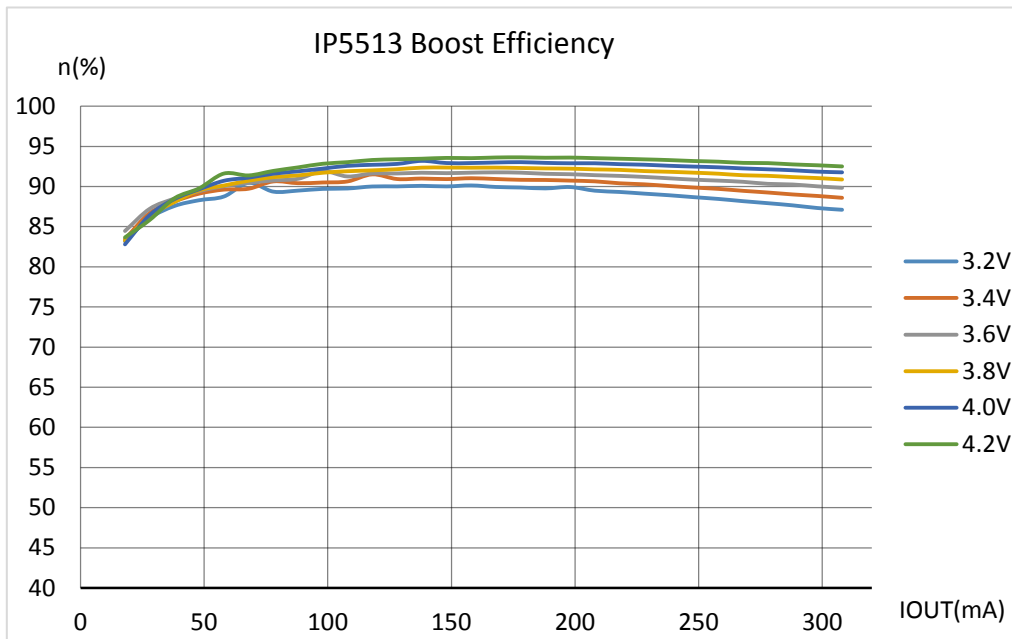


Figure4 IP5513 Boost Efficiency Curve

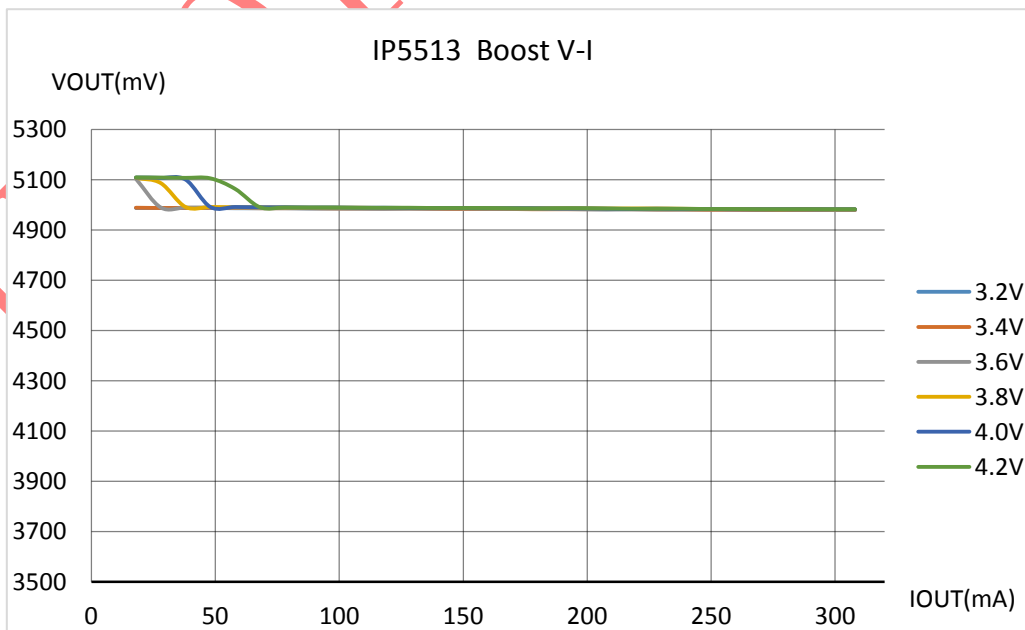


Figure5 IP5513 Boost Output V-I Curve

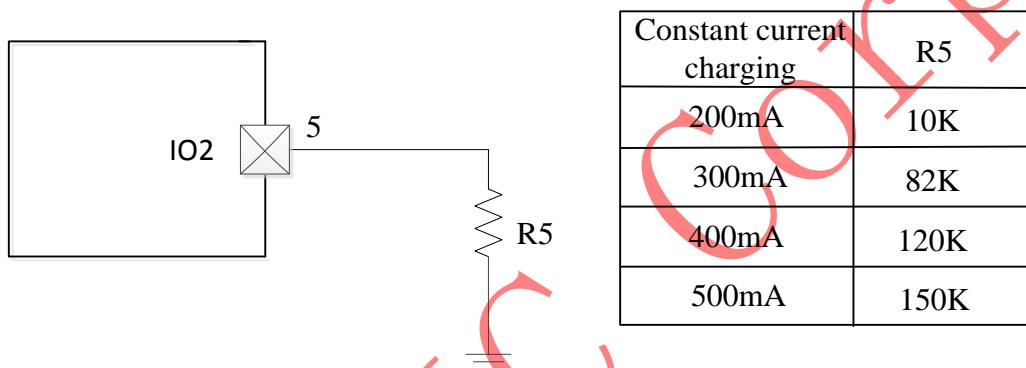


## Charge

IP5513 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.

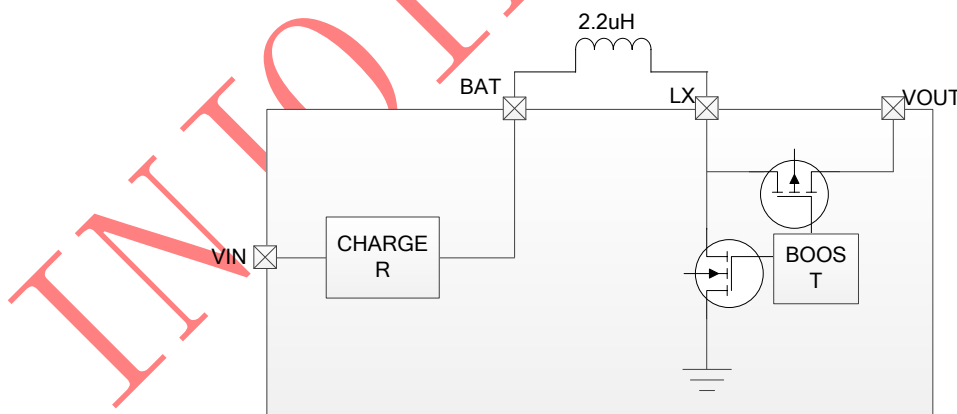
IP5513 supports max 500mA linear charging, According to the IC temperature and input voltage, IP5513 can intelligently adjust charging current.

IP5513 can select the constant current charging current of the battery by connecting different resistors on the IO2 pin.



**Figure6 Constant Charging Current Setting Circuit**

IP5513 has a built-in power path management. When the battery voltage is greater than 3.2V, it supports simultaneous charging and discharging. When the battery voltage is less than 3.1V, it does not support simultaneous charging and discharging, the battery is charged firstly.



**Figure7 IP5513 Power Path Diagram**

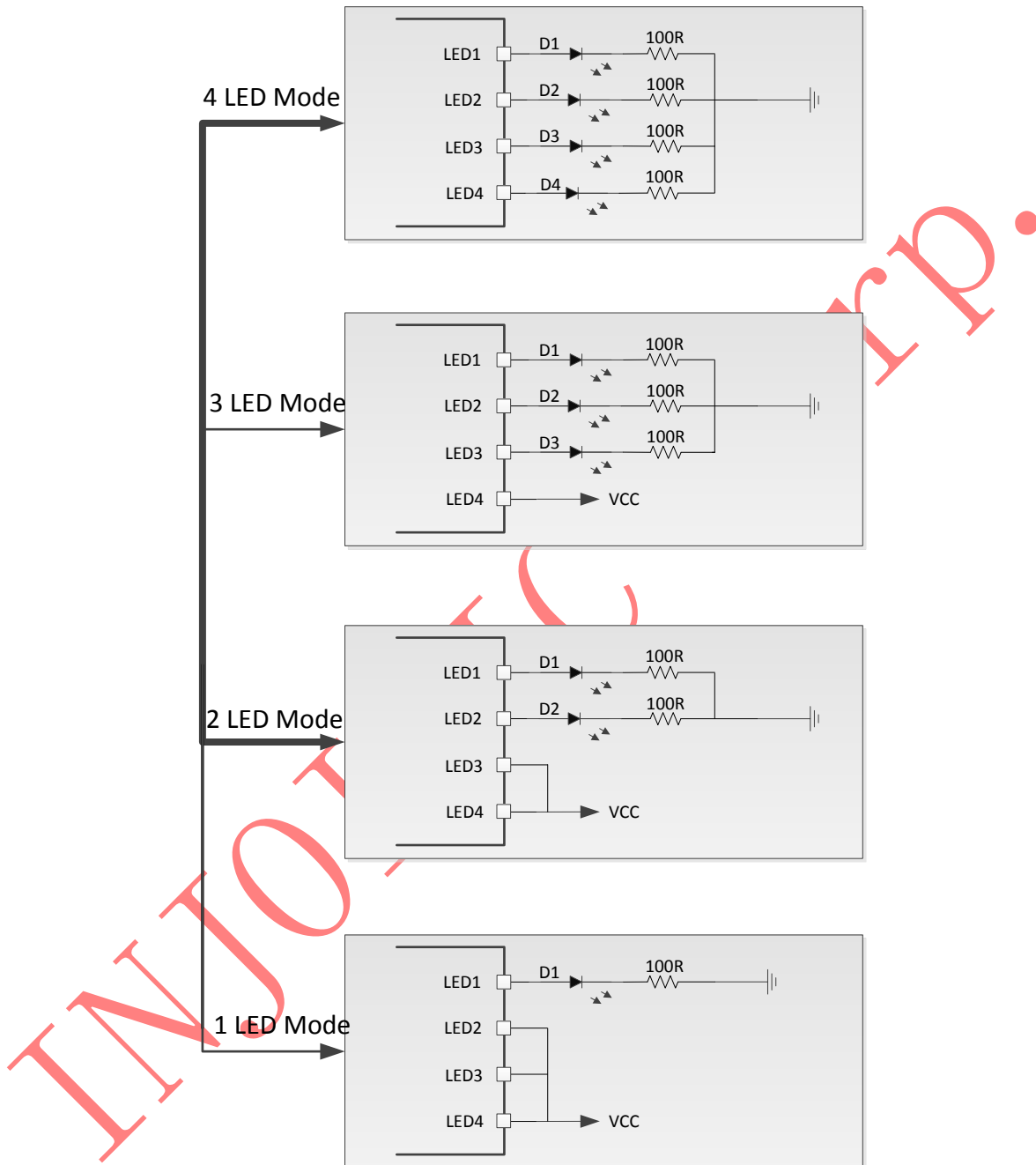
## Battery level display

IP5513 has a built-in power algorithm, which can accurately display the remaining battery power according to the cell capacity.

IP5513 can support 1/2/3/4 LED battery indicator, and the system can automatically identify several LED modes.

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## LED light display mode



**Figure8 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	dischareging	on
	low	1Hz blink

**188 digital tube display mode**

Digital tube	Charge		Discharge	
	charging	full	C < 5%	C > 5%
188 type (YF2252SR-5)	0-99% 0.5HZ Units and tens blink together	LED on 100%	0-5% 1HZ Units blink	5%-100% on

(未注尺寸公差 Unspecified Tolerances is:  $\pm 0.2$  发光颜色: 红色)

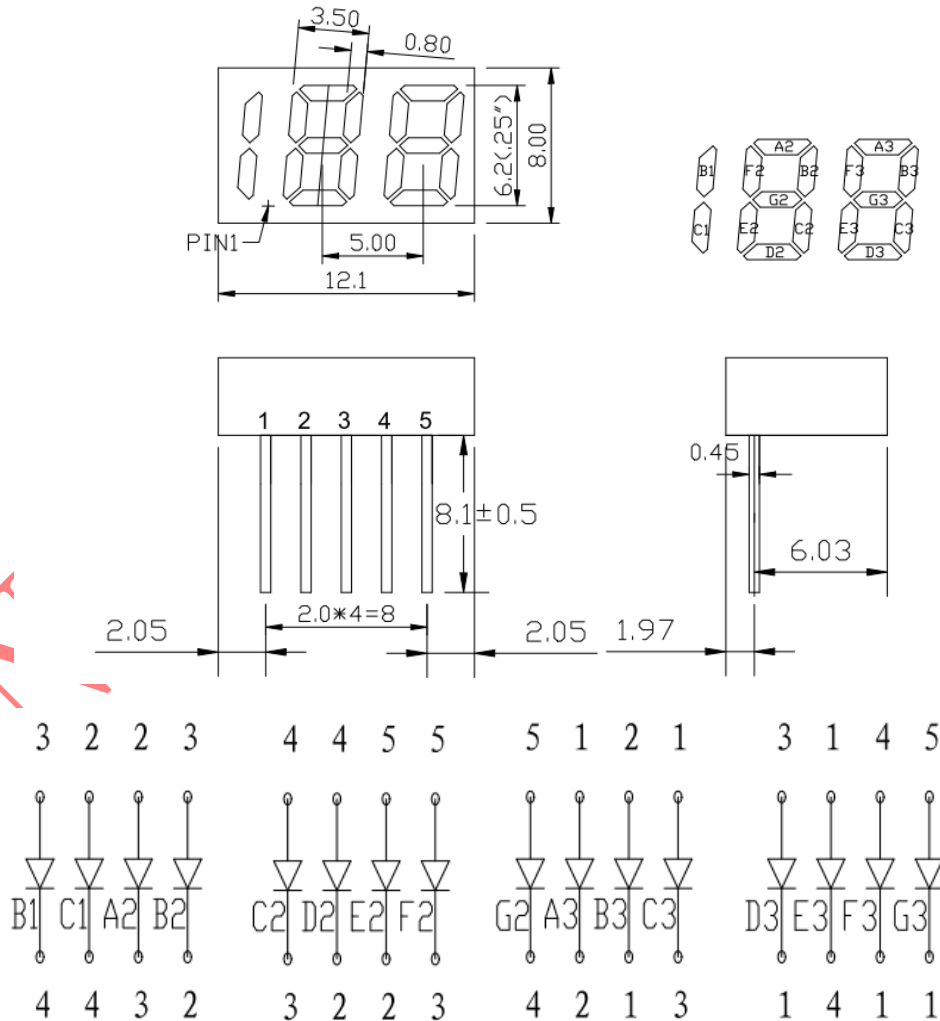


Figure9 5 PIN 188 Digital tube Diagram

## NTC

IP5513 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.

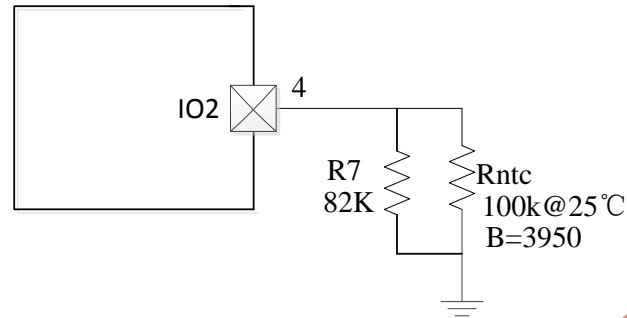


Figure10 NTC Circuit

### 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 IO2 pin shall be connected 51K to GND. IO2 pin shall not float, otherwise abnormal charging and discharging may be caused.

## KEY/EN Function

IP5513 Pin2 can support button or Hall switch, only one of them can be selected.

IP5513\_BZ series, Pin2 can only be used as a key, which can be connected with a key to realize the function of power on / off.

IP5513\_EN series, Pin2 can only be used as EN and can be connected with Hall switch, when Pin2 is high, Vout output is 0V; when Pin2 is used as EN function, the effective low-level signal of Pin2 is less than 0.4V, and the effective high-level signal of Pin2 is greater than 0.8V.

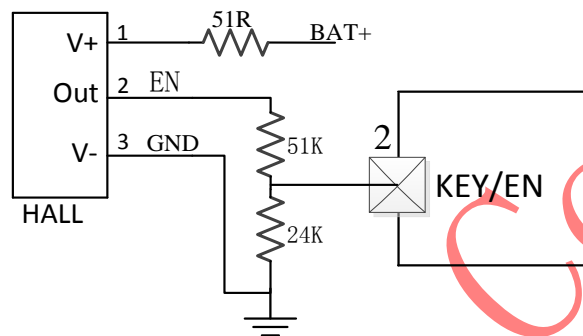


Figure11 Hall device circuit diagram

## Plug-in detection

Once detecting the insertion of the earphone, the IP5513 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 IP5513 supports light-load auto standby function. When the earphone's load current on PH1 and PH2 are less than 4mA for 6 seconds, IP5513 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 IP5513 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 IP5513 can enter standby mode, but the earphone cannot enter the standby mode, then gradually reduce the R8.
3. If IP5513 can enter standby, but it cannot 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 IP5513 can enter standby mode, and the earphone can enter standby mode, and IP5513 can be waked up by the plug-in of earphone.

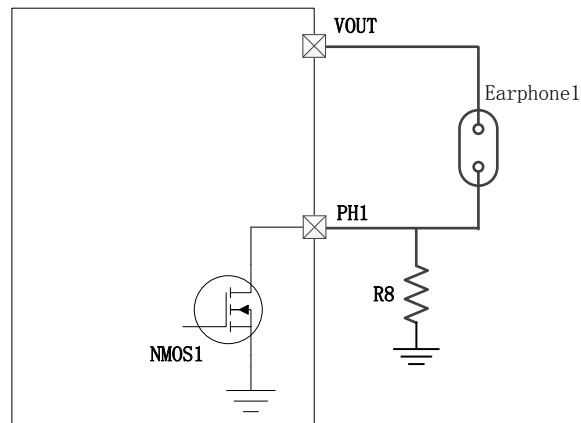


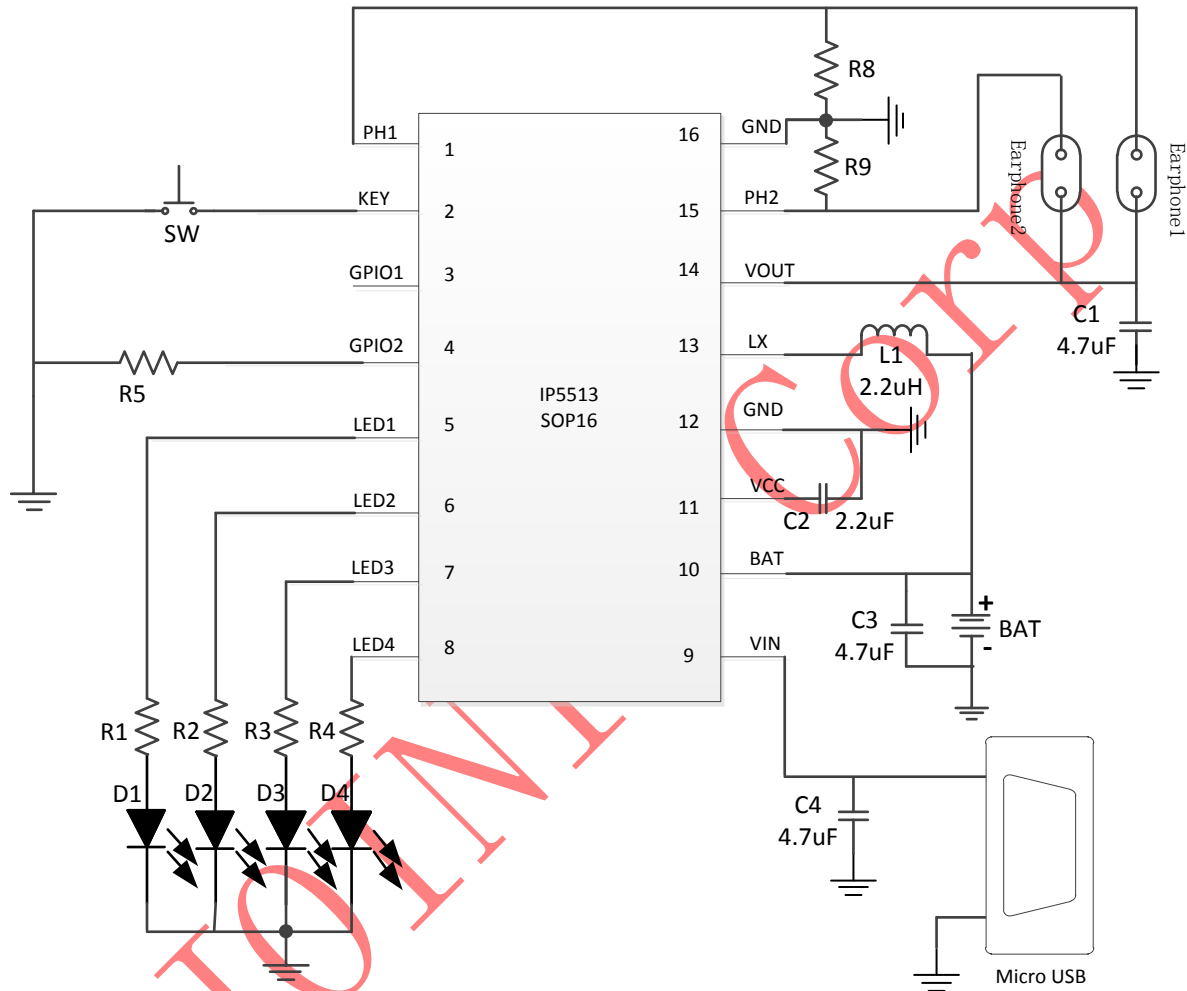
Figure12 IP5513 Earphone Standby Resistance Adjustment Diagram

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## 10. Typical Application Diagram

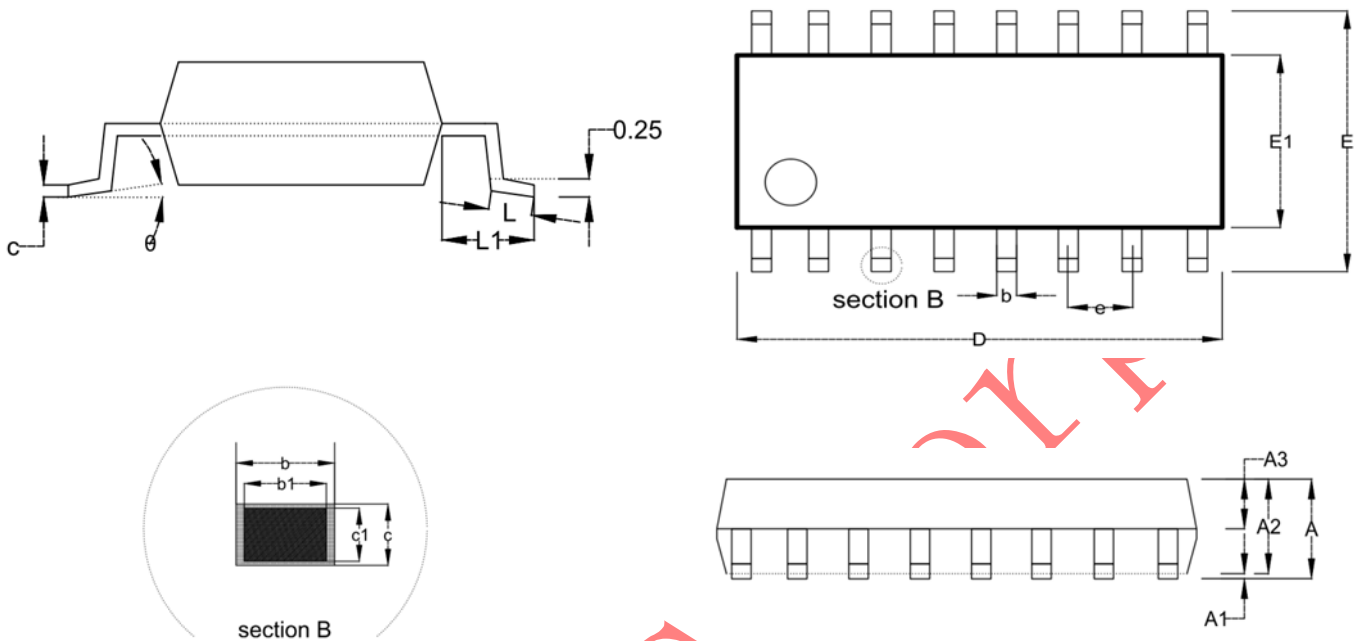
Total solution of IP5513 charging Box is merely realized by passive devices of inductor, capacitor capacitors and resistors.(The solution with HALL switch or 188 digital tube LEDS need to be customized separately)



1. Adjust R1/2/3/4 according to the LED light brightness.
2. R5 is the constant charging current Setting.
3. Please adjust R8/R9 according to different Bluetooth earphone solutions

Figure13 IP5513 Typical Application Diagram

## 11. Package





SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	--	--	1.75
A1	0.05	--	0.225
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.39	--	0.48
b1	0.38	0.41	0.43
c	0.21	--	0.26
c1	0.19	0.20	0.21
D	9.70	9.90	10.10
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	1.27BSC		
h	0.25	--	0.50
L	0.50	--	0.80
L1	1.05BSC		
$\theta$	0	--	8°

## 12. Mark description



说明:

- 1、  ——英集芯标志
- 2、 IP5513 ——产品型号
- 3、 LLLLLLLL——生产批号
- 4、  ——Pin 1脚位置标识

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