TWS Bluetooth Earphone Charging Box SOC integrated with MCU

1 Features

- **Discharge**
  - ✧ Output capacity: 5V/300mA
  - ✧ Up to 93% 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
- **Battery indicators**
  - ✧ Built-in 12bits ADC , accurate calculation of battery capacity
  - ✧ Supports 4/3/2/1 LED battery indicator
- **Serial communication**
  - ✧ Double UART, support earphone independent communication function
- **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 20uA minimum
  - ✧ Shipping mode standby current maximum value is 3uA
- **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 30V
  - ✧ ESD 4KV
- **In-depth customization**
  - ✧ Flexible and low-cost customized program
- **Package: QFN24 (4*4*0.75mm)**

2 Applications

- TWS Bluetooth Earphone Charging Box
- Lithium Battery Portable Device

3 Description

IP5518V 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.

IP5518V is highly integrated with abundant functions, which makes the total solution with minimized-size and low-cost BOM.

The synchronous 5V-boost system of IP5518V 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.

IP5518V's linear charger supplies max 500mA charging current. With the change of IC temperature and input voltage, IP5518V can automatically adjust the charging current.

IP5518V 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, the standby current can be reduced to 20uA, and the shipping mode standby current maximum value is 3uA. The earphone's charge-end current can be Flexible and customizable, such as 4mA or 8mA.

IP5518V can support 1/2/3/4 LED battery indicator, The built-in 12bits ADC can accurately calculate the Chargering Box's battery capacity.

IP5518V is packaged with QFN24(4*4*0.75mm).

Contents

4 Reversion History

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

Version V1.00 changed in Dec 2022	Page
● First Release	1

Version V1.00 changed to version V1.01 in Mar 2024	Page
● Chapter 11: Increased the range of shipping mode standby current	9

5 Simplified application schematic

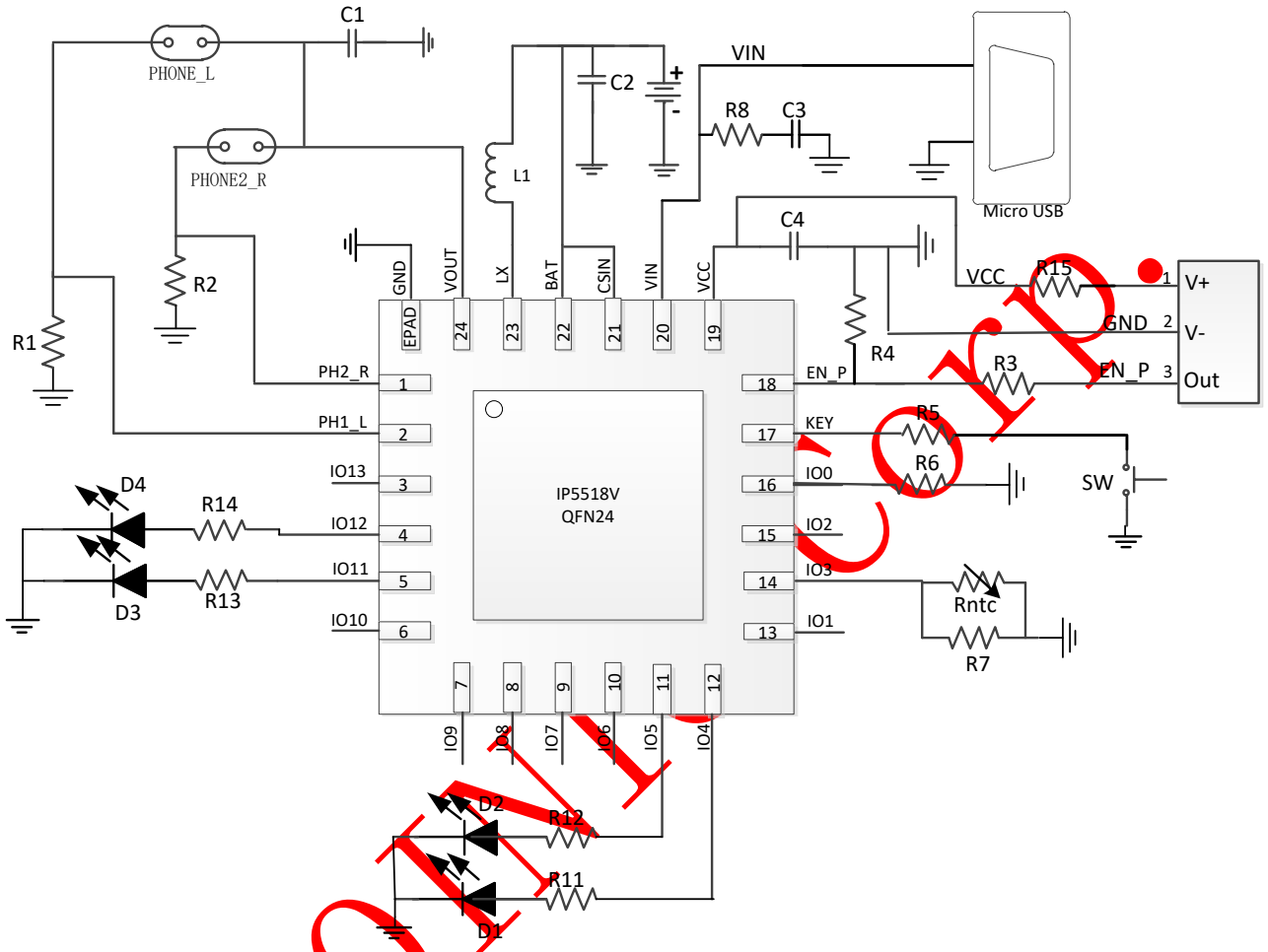


Figure1 IP5518V Simplified Application Diagram

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
IP5518V	300mA	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

not supported:-

7 Pin Definition

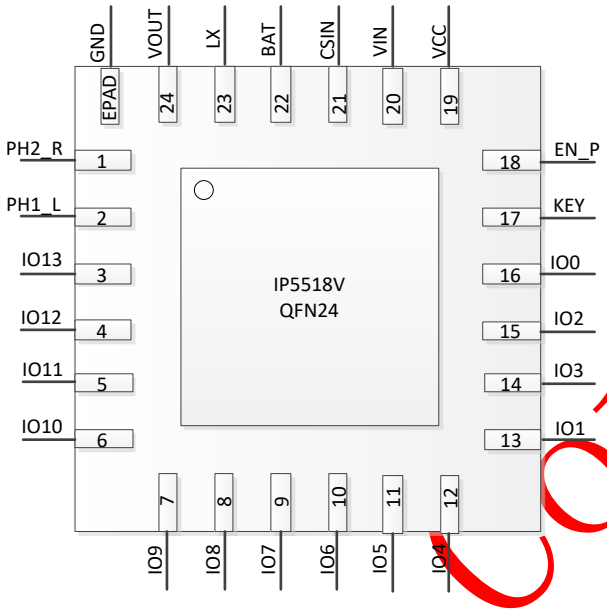


Figure2 IP5518V Pin Assignments

7.1 Pin description

Pin Num	Pin Name	Description
1	PH2_R	Earphone 2 negative
2	PH1_L	Earphone 1 negative
3	IO13	IO13
4	IO12	IO12, LED driver,can be reused as breathing light
5	IO11	IO11, LED driver,can be reused as breathing light
6	IO10	IO10
7	IO9	IO9, can be reused as UART0
8	IO8	IO8, can be reused as UART1
9	IO7	IO7, can be reused as UART0
10	IO6	IO6, can be reused as UART1
11	IO5	IO5, LED driver,can be reused as breathing light
12	IO4	IO4, LED driver,can be reused as breathing light
13	IO1	IO1, can be reused as ADC
14	IO3	IO3, NTC function
15	IO2	IO2, can be reused as ADC
16	IO0	IO0, charging current setting pin
17	KEY	KEY
18	EN_P	Hall switch input signal, pull down by default
19	VCC	LDO output pin

20	VIN	5V input pin
21	CSIN	Battery voltage positive pin
22	BAT	Battery voltage positive pin
23	LX	DCDC switch node
24	VOUT	Boost5V output
Epad	GND	Ground

8 System Diagram

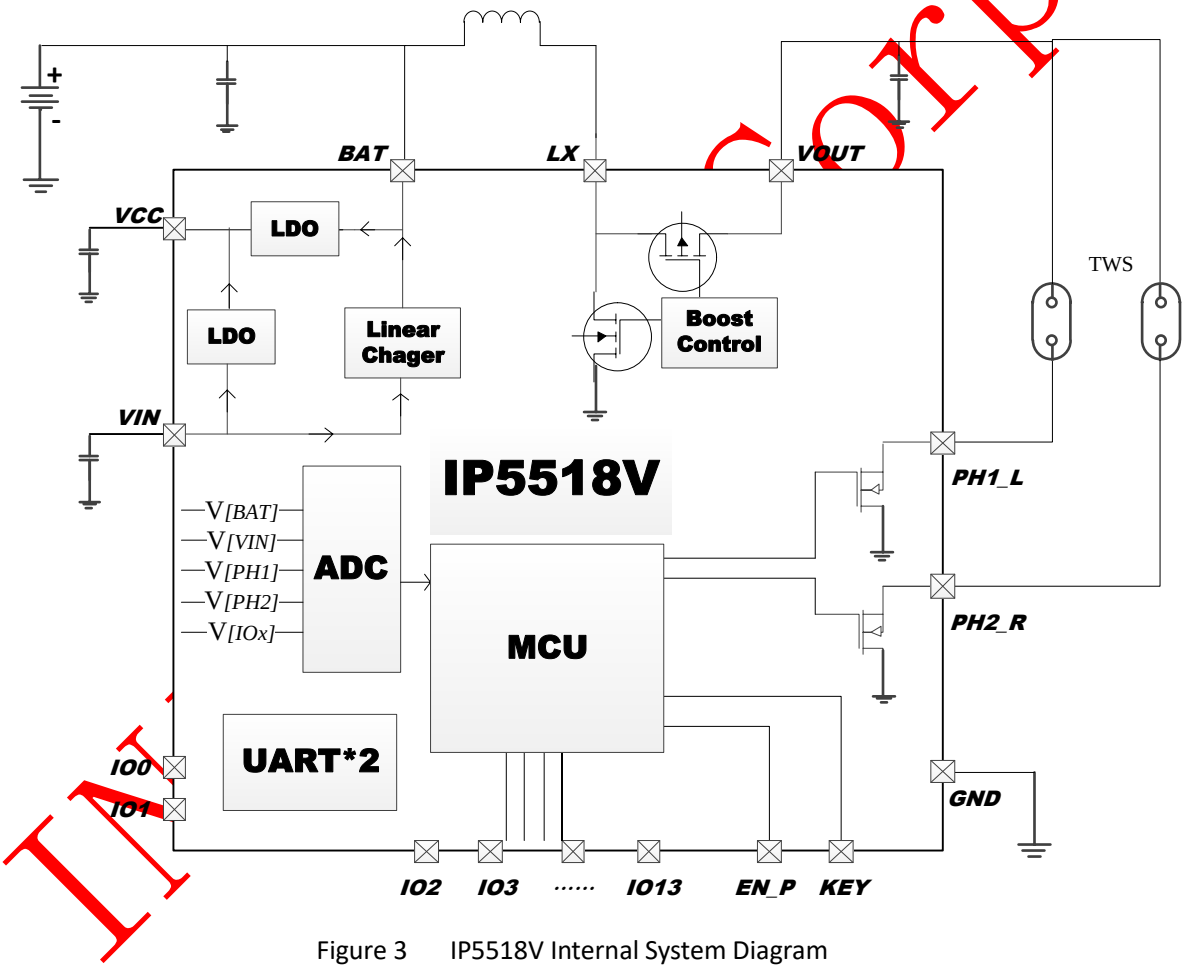


Figure 3 IP5518V Internal System Diagram

9 Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Input Voltage Range	V_{IN}	-0.3 ~ 30	V
	BAT,CSIN,LX,PH1_L,PH2_R	-0.3 ~ 10	V
	VOUT	-0.3 ~ 10	V
IO Voltage Range	IO0-IO13	-0.3 ~ 6.5	V
Junction Temperature Range	T_J	-40 ~ 150	℃
Storage Temperature Range	Tstg	-60 ~ 150	℃
Thermal Resistance (Junction to Ambient)	θ_{JA}	50	℃/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.

10 Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input Voltage	V_{IN}	4.5	5	6.0	V
Operating Temperature	T_A	-10	--	70	℃

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

11 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	6.0	V
Input Over Voltage	V_{INOV}			6		V
VIN activation voltage	V_{INOk}		3.0	3.2	3.4	V
Input Under Voltage	V_{INUV}		4.3	4.5	4.7	V
Constant Charge Voltage	$CV_{4.2V}$	4.2V battery	4.15	4.20	4.25	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	$Ivin_{stop}$	VIN=5V		30		mA
Charge Current	I_{VIN}	VIN=5V, VBAT=3.7V, Set the charge current=300mA	260	300	340	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}		8	16	24	Hours
Boost System						
Battery Operation Voltage	V_{BAT}		3.0	3.7	4.4	V
Low Power Shutdown Voltage	V_{BATLOW}	IOUT=300mA	2.9	3.0	3.1	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	5.1	5.2	V
		VBAT=3.7V @300mA	4.85	5.1	5.2	V
Output Voltage Ripple	ΔV_{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
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	VBAT=3.7V	3.1		3.3	V
Battery Input Standby Current	I_{STB1}	VIN=0V，VBAT=3.0-4.2V	15	20	25	uA
Shipping Mode Standby Current	I_{STB2}	VIN=0V，VBAT=3.0-4.2V	1	2	3	uA
IO Driving Current	I_{Gpio}		4	6	8	mA
Light Load Shut Down Detect Time	T_{loadD}	Load current less than 4mA	7	8	9	s

Light Load Shut Down Current	I_{plout}	VBAT=3.7V, The load current of both headphones must be less than Iplout 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	℃
Thermal Shut Down Hysteresis	ΔT_{OTP}		30	40	50	℃

12 Function Description

12.1 Boost

IP5518V 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 protectionfunction, ensuring the reliability and stability of system operation.

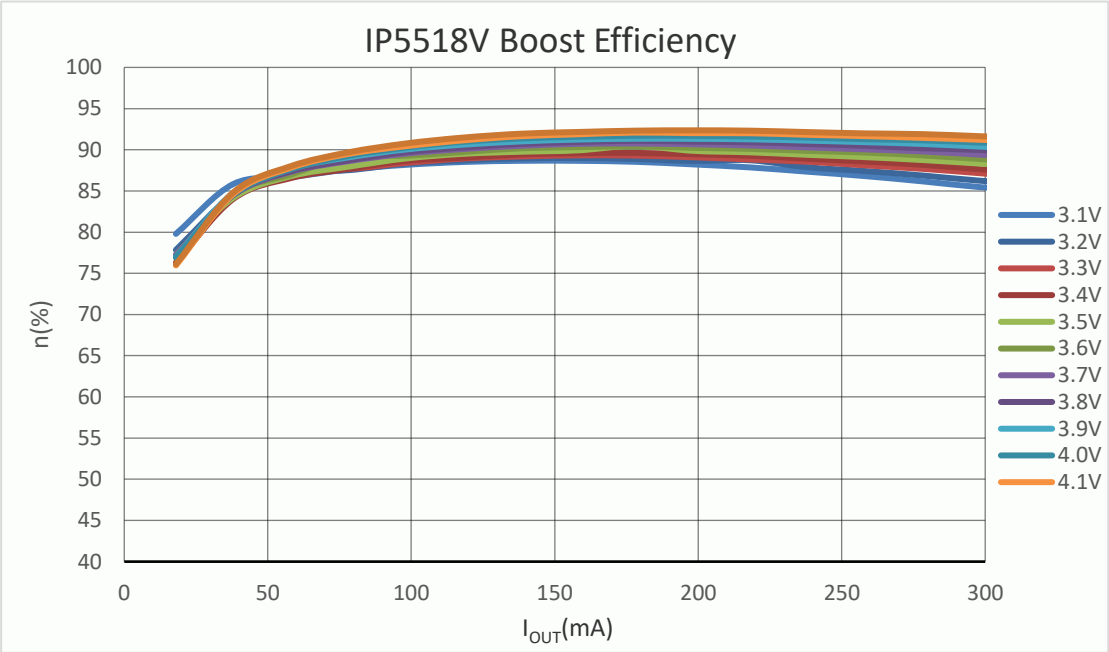


Figure4 IP5518V Boost Efficiency Curve

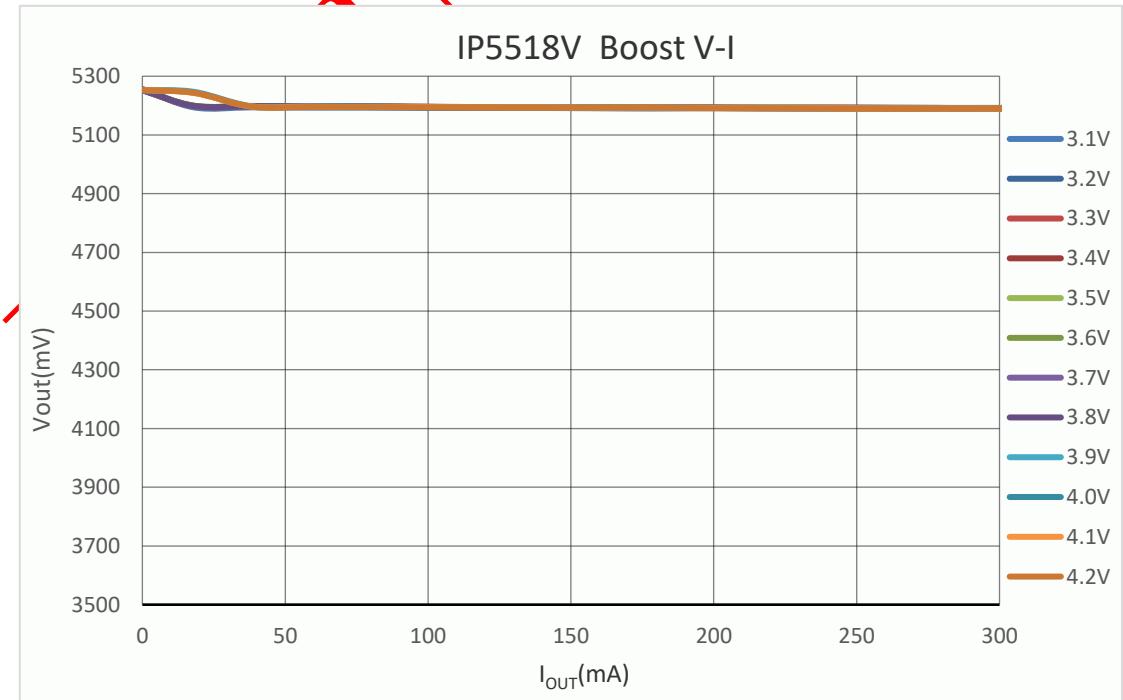


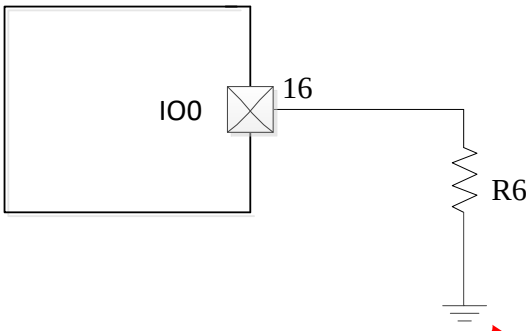
Figure5 IP5518V Boost Output V-I Curve

12.2 Charge

IP5518V 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.

IP5518V supports max 500mA linear charging, According to the IC temperature and input voltage, IP5518V can intelligently adjust charging current.

IP5518V can select the constant current charging current of the battery by connecting different resistors on the IO0 pin.



charging current	R6
200mA	10K
300mA	82K
400mA	120K
500mA	150K

Figure6 Constant Charging Current Setting Circuit

IP5518V has a built-in power path management. When the battery voltage is greater than 3.3V, 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.

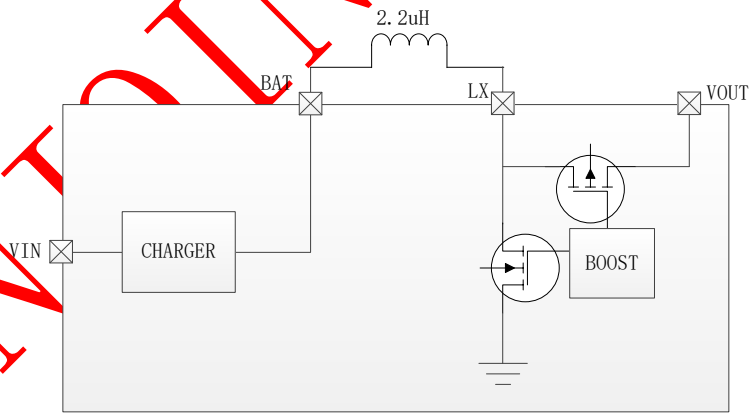


Figure7 IP5518V Power Path Diagram

*IP5518V cannot indicate the overvoltage state of VIN after VIN exceeds 6V. This kind of lamp display needs to be realized with additional circuit, Please contact INJOINIC technical support department.

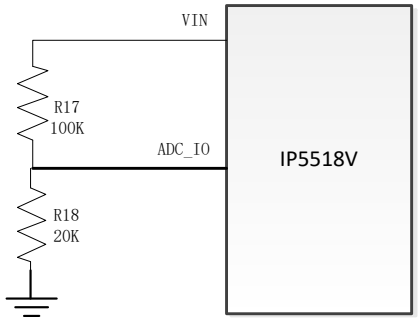


Figure8 IP5518V detection overvoltage diagram

12.3 Battery level display

IP5518V has a built-in power algorithm, which can accurately display the remaining battery power according to the cell capacity.

IP5518V can support 1/2/3/4 LED battery indicator, and the system can automatically identify several LED modes.

IP5518V can also support other power displays such as breathing lights and 188 digital tubes. Such special lights need to be customized separately. Please contact INJOINIC technical support department.

12.3.1 LED light display mode

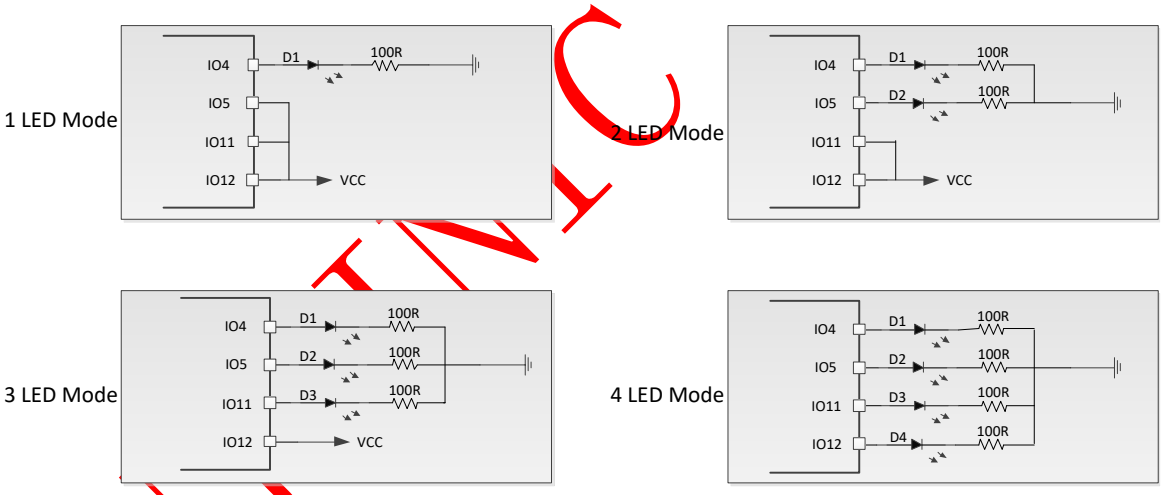


Figure9 LED Mode Seleciton Circuit

■ 4 LED Mode

Discharge

Battery capacity(c)(%)	LED1	LED2	LED3	LED4
C≥75%	on	on	on	on
50%≤C＜75%	on	on	on	off
25%≤C＜50%	on	on	off	off
3%≤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%≤C	on	on	on	0.5Hz blink
50%≤C＜75%	on	on	0.5Hz blink	off
25%≤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≥66%	on	on	on
33%≤C＜66%	on	on	off
3%≤C＜33%	on	off	off
0%＜C＜3%	1Hz blink	off	off

Charge

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

■ 2 LED Mode

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

■ 1 LED Mode

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

12.4 NTC

IP5518V 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.

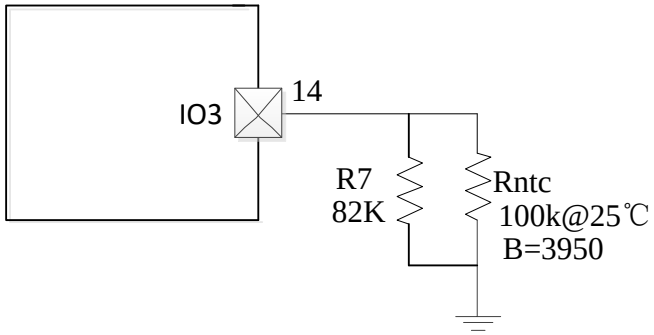


Figure10 NTC Circuit

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 0.57V meaning the battery temperature is above 45 centigrade, then stop charging the battery;

Under discharging state:

Voltage on NTC resistance is higher than 1.42V meaning the battery temperature is under -10 centigrade, stop discharging;

Voltage on NTC resistance is lower than 0.57V meaning the battery temperature is above 45 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.

12.5 plug-in/plug-out detection

Once detecting the insertion of the earphone, the IP5518V 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 IP5518V supports light-load auto standby function. When the earphone's load current on PH1_L and PH2_R are less than 4mA for 8 seconds, IP5518V 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 IP5518V 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 R1/R2 on PH1_L/PH2_R. Taking PH1_L as an example, the adjustment method is as follows:

1. R1 default resistance is 51K

2. If IP5518V can enters standby mode , but the earphone cannot enter the standby mode, then gradually reduce the R1.

3. If IP5518V can enters standby , but it can not be waked up by the earphone's plug-in, then gradually increase the R1.

4. Repeat steps 2/3 until you find a suitable resistor R1, which makes IP5518V can enter standby mode, and the earphone can enter stanby mode,and IP5518V can be waked up by the plug-in of earphone.

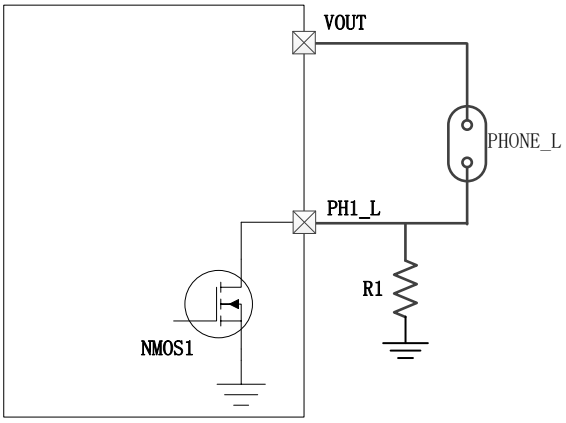


Figure11 IP5518V Earphone Standby Resistance Adjustment Diagram

12.6 Earphone communication function

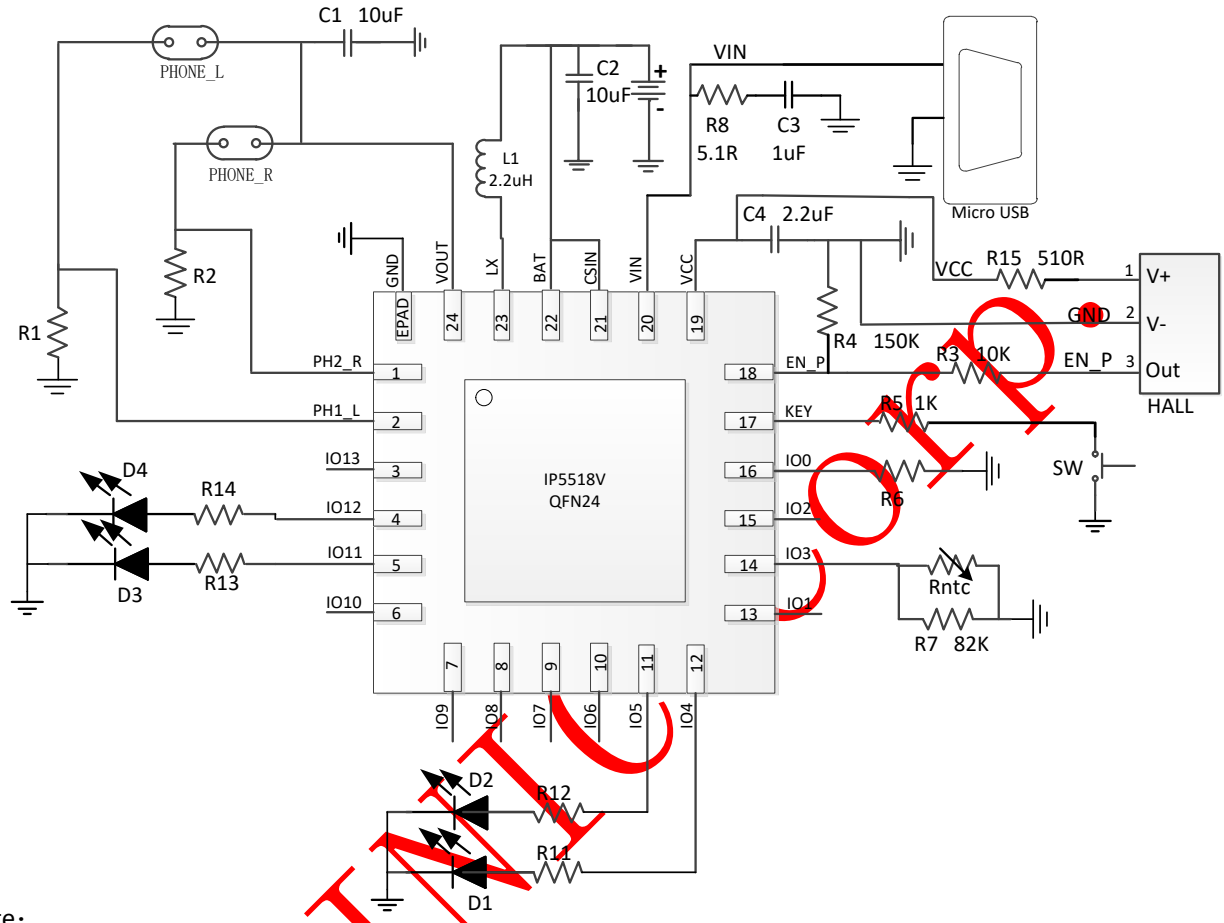
IP5518V supports UART communication function of two independent channels, and can communicate with various earphone solutions.

As each Bluetooth headset solution has its own communication mode, the hardware circuit and software code need to be customized. If you need such functions, Please contact INJOINIC technical support department.

12.7 VCC

The VCC is an internally integrated 3.1V LDO. Its load capacity is 30mA. A 2.2uF capacitor needs to be connected in parallel between VCC and GND.

13 Typical Application Diagram



Note：

1、R11/12/13/14 Please adjust the resistance value according to the actual LED lamp brightness

2、If NTC function is not required, R7 needs to be 51K resistor

3、R6 Please configure different resistance values according to charging current requirements

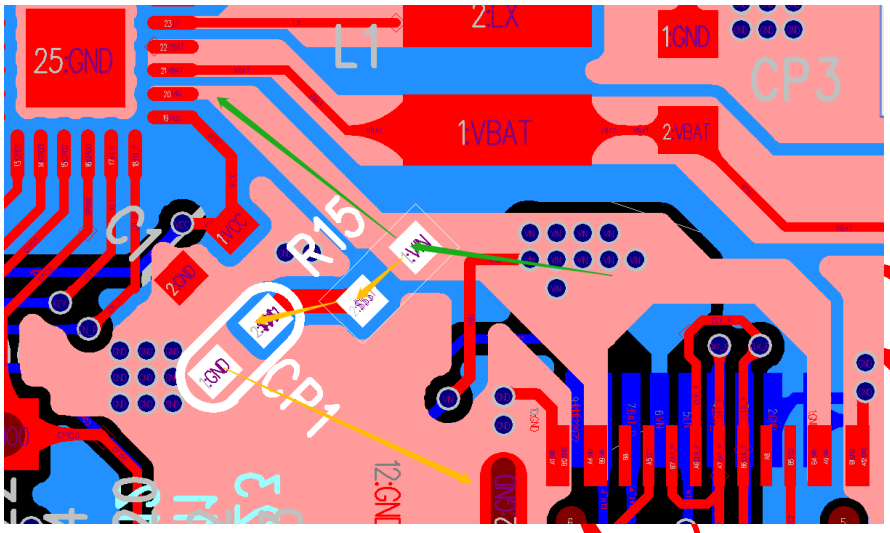
4、R1/R2 Please adjust the corresponding resistance according to different Bluetooth headset solutions

5、C3 requires a capacitance of 0603 package size and withstand voltage not less than 35V, and R8 also requires a resistance of 0603 package size

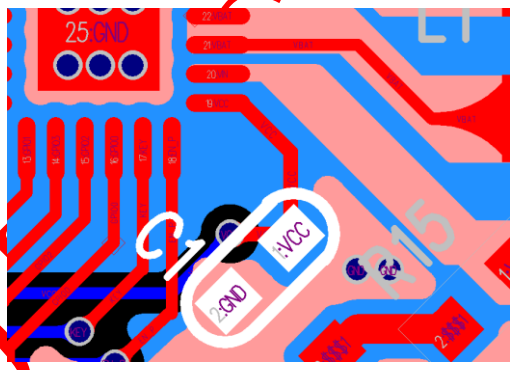
Figure12 IP5518V Typical Application Diagram

14 PCB LAYOUT

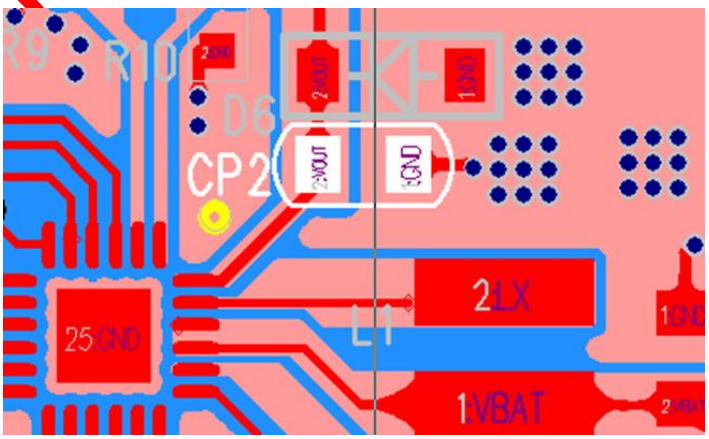
1. VIN capacitor should be placed close to VIN PIN, The ground loop should be as short as possible:



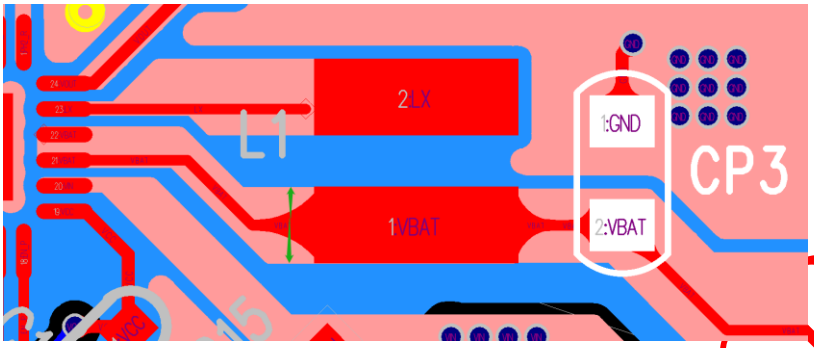
2. VCC capacitor placed close to the VCC pin, When externally connected to other circuits for power supply, this branch needs to be led out from behind the VCC capacitor and connected in series with a current limiting resistor:



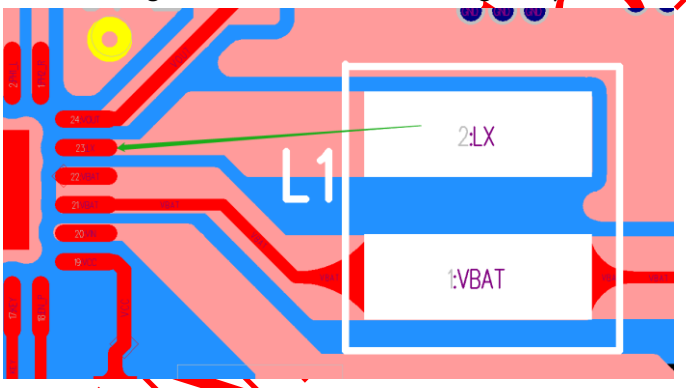
3. VOUT capacitor placed close to the VOUT pin:



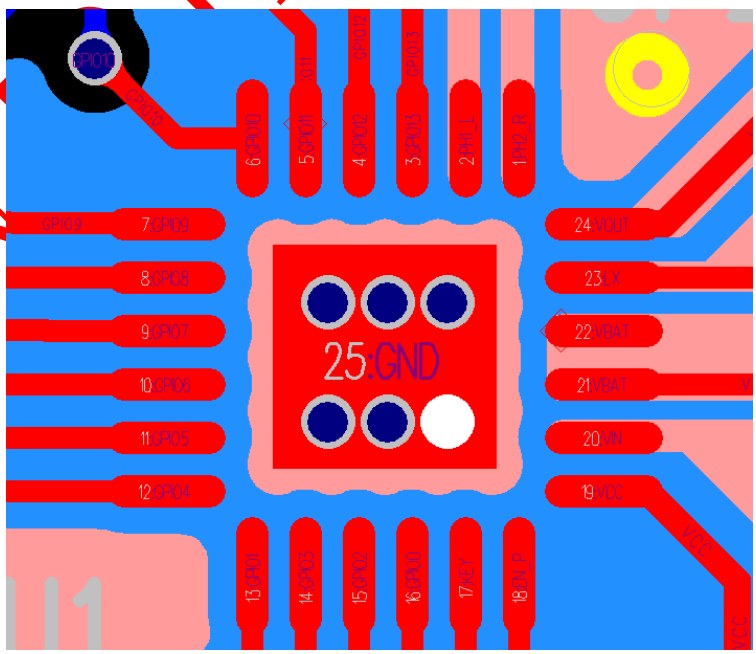
4. BAT and CSIN pins are shorted together as the positive terminal of the linear charger output connected to the battery. The wiring width needs to be increased to reduce the line resistance to ensure the passage of large current; BAT capacitors should be placed as close to the chip as possible：



5. LX PIN is the connection PIN between the internal boost circuit and the inductance. There is a high-frequency switch signal on the LX wiring, so the wiring should be as short and straight as possible：



6. It is forbidden to layout any other networks wire under the 5518 chip. Only GND vias need to be drilled under the EPAD：

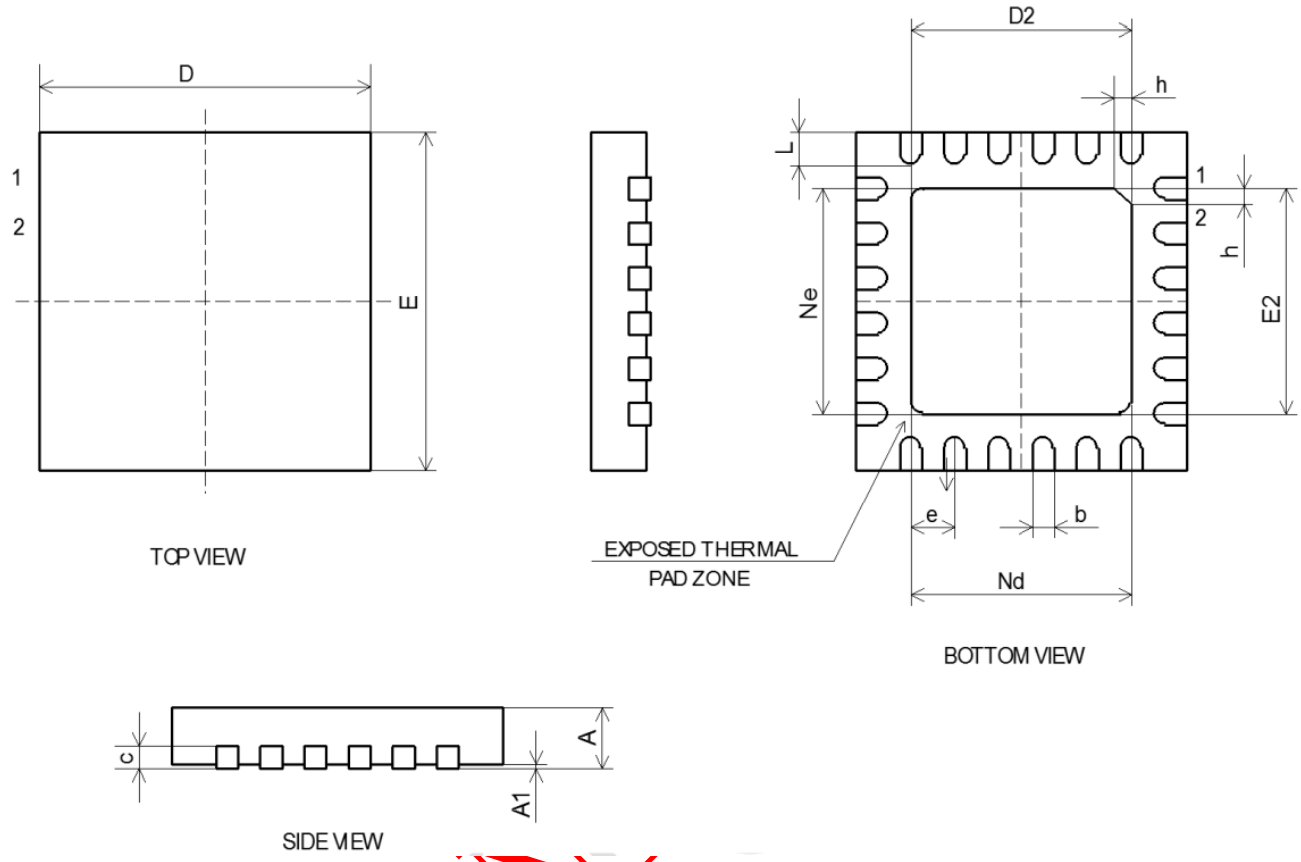


15 IC Mark description

Note:
1、 --Injoinic Logo
2、IP5518V --Part Number
3、XXXXXXXX --Manufacture number
4、 --PIN1 location

Figure13 IP5518V Mark description

16 Package



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	-	0.02	0.05
b	0.18	0.25	0.30
c	0.18	0.20	0.25
D	3.90	4.00	4.10
D2	2.40	2.50	2.60
e	0.50BSC		
Ne	2.50BSC		
Nd	2.50BSC		
E	3.90	4.00	4.10
E2	2.40	2.50	2.60
L	0.35	0.40	0.45
h	0.30	0.35	0.40

17 IMPORTANT NOTICE

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